Iowa Water Center
Annual Technical Report
FY 2012

Introduction

The Iowa Water Center is a multi-campus and multi-organizational center focusing on research, teaching and outreach activities. Its goal is to encourage and promote interdisciplinary, inter-institutional water research that can improve Iowa's water quality and provide adequate water supplies to meet both current and future needs of the state. The Iowa Water Center continues to build statewide linkages between universities and public and private sectors and to promote education, research, and information transfer on water resources and water quality issues in Iowa. The Center also plays a vital role in identifying critical water research needs and providing the funding or impetus needed to initiate research that cannot or is not being conducted through other means. Water quality remains a critical concern in Iowa.

Our ability to manage water during extreme climatic events has been tested in recent years with the flood events in Iowa of 2010 and compounded with the historic drought in 2012. Managing Iowa’s water resources for flood or for drought is a difficult task. More challenging would be managing for the occurrence of flood and/or drought in rapid succession. Climatologists expect a warmer atmosphere in the coming decades, with more extreme fluctuations in our weather. The ability to manage and prepare for rapid variations in weather, especially precipitation, should be questioned. Do our land management systems perform well under both sides of the precipitation norm? How will water quality and quantity be affected under different cycles of extreme weather? Are the tools available to monitor and respond in adequate time to avoid adverse consequences to Iowa’s economy and human health? A variety of issues linking land management and water quantity and quality at multiple scales require further study. Identifying Best Management Practices for managing water quantity and for acceptable water quality during rapid cycle of climate extremes will be a primary focus again this year and in the years to come. The Iowa Water Center plays a role in addressing these questions through administering the 104B program and garnering additional funds for other research projects.

Research Program Introduction

The Iowa Water Center has continued its work on water quality and water quantity, with particular emphasis on the role that changes in climate patterns have on water management. Iowa is somewhat unique in that it lies on a sharp precipitation gradient from east to west, making it a battle ground at times between water excess and water deficits. Our ability to manage water during extreme climatic events has been tested in recent years with the flood events in Iowa of 2010 and the drought of 2012. Managing Iowa's water resources for flood or for drought is a difficult task.More challenging would be managing for the occurrence of flood and/or drought in rapid succession. Climatologists expect a warmer atmosphere in the coming decades, with more extreme fluctuations in our weather. The 2012 drought brought this into clear perspective.

The ability to manage and prepare for rapid variations in weather, especially precipitation, should be questioned. Do our land management systems perform well under both sides of the precipitation norm? How will water quality and quantity be affected under different cycles of extreme weather? Are the tools available to monitor and respond in adequate time to avoid adverse consequences to Iowa’s economy and human health? A variety of issues linking land management and water quantity and quality at multiple scales require further study. Identifying Best Management Practices for managing water quantity and for acceptable water quality during rapid cycle of climate extremes has been a primary focus this year and will be a focus in the years to come. The Iowa Water Center plays a role in addressing these questions through administering the 104B program and garnering additional funds for other research projects.

Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS.

Basic Information

Title:	Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS.
Project Number:	2011IA241B
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Research Category:	Climate and Hydrologic Processes
Focus Category:	Non Point Pollution, Hydrology, Models
Descriptors:	
Principal Investigators:	Ramanathan Sugumaran, John DeGroote

Publications

There are no publications.

Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS

Basic Information

Title: Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS.

Principal Investigators: Ramanathan Sugumaran, John DeGroote, Bernard Conrad

External Collaborators: Paul Meyermann, John Voorhees, Rebecca Kautern

Start Date: September 2011

End Date: May 2012

Publications

1. Conrad, B., Ramanathan, S., DeGroote, John. 2012. Urban Storm Water modeling utilizing LiDAR and GIS. *Journal of Spatial hydrology*, planned for June 2012 submission.

2. Conrad, B., Ramanathan, S., DeGroote, John. 2012. Urban Storm Water Planning Utilizing LiDAR and GIS. 2012 Association of American Geographers (AAG) Annual Meeting. New York, New York.

3. Conrad, B., Ramanathan, S., DeGroote, John. 2012. Urban Storm Water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS. 2012 Iowa Water Conference. Ames, Iowa

5. Conrad, B., Ramanathan, S., DeGroote, John. 2012. Urban Storm Water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS. 2012 Research in the Capital. Des Moines, Iowa.

Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM

Problem and Research Objectives

Urban watersheds are composed of a complicated spatial fabric and are influenced by a wide range of economic, policy, and public interest drivers and constraints. With increased regulation of storm water discharges taking place on a national basis, there are greater pressures on municipalities to develop effective urban storm water management strategies. Thus, there is a great need for effective tools which can aid the design and execution of such strategies by identifying hot-spot areas contributing to excessive discharges and pollutants and to evaluate potential best management practices (Wong 2010). Although concern over urban storm water runoff quantity and quality has grown, there has been a lack of accurate spatially explicit models for better storm-water planning.

Urbanization of watersheds has been known to create problems in regards to water quality (Roesner 2001; Walsh 2000). Urban areas consist of manmade impervious structures that reduce infiltration made possible by permeable surfaces with streets considered to be the major contributor of pollutant runoff (Sartor, 1974). Urban runoff comes from a variety of different sources such as streets, sidewalks, and roofs (Bochis, 2005) which is conveyed by advanced water management systems quickly to natural waterways. However, water quality is important for human uses and ecological reasons to ensure that water sources do not become tainted from various pollutants such as sediment and phosphorus. Better Management Practices (BMPs) can reduce the amount of pollutants being discharged as well as slow down water movement by creating more effective infiltration areas (D'Arcy 2000). To effectively implement BMPs requires topographic knowledge of an area to determine optimal locations of such devices, such as biofiltration devices and detention ponds.

Determining urban drainage areas and patterns is a complex process that is drastically enhanced by incorporating a Geographic Information System (GIS) (Sui, 1999). GIS has capabilities to model hydrology to determine hazards or vulnerability by layering parameters including slope, soil characteristics, precipitation, and others (Clark 1998). Together with a Digital Elevation Model (DEM), GIS can be used to process and determine hydrological features of the ground's surface (Garbrecht 1999). DEMs are available at different spatial resolutions and it is understood that a higher spatial resolution will result in more accurate results. Higher spatial resolution DEMs are increasingly being developed through LiDAR (Light Detection and Ranging) technology. Iowa is one of the first states in the United States to collect LiDAR data statewide.

To model urban hydrology a DEM is needed to provide an accurate topographic representation of the study area. Using a DEM with high spatial resolution is important to accurately display appropriate drainage areas (Liu 2005). LiDAR has become much more commonly used to create high spatial resolution DEMs available for analysis (Hodgson, 2003). Higher spatial resolution can be prone to errors, although if it is preprocessed carefully to remove errors, LiDAR data can lead to improved results (Barber 2005). Figure 1 shows a comparison between 1, 5, 10, and 30 meter DEMs created using LiDAR data.

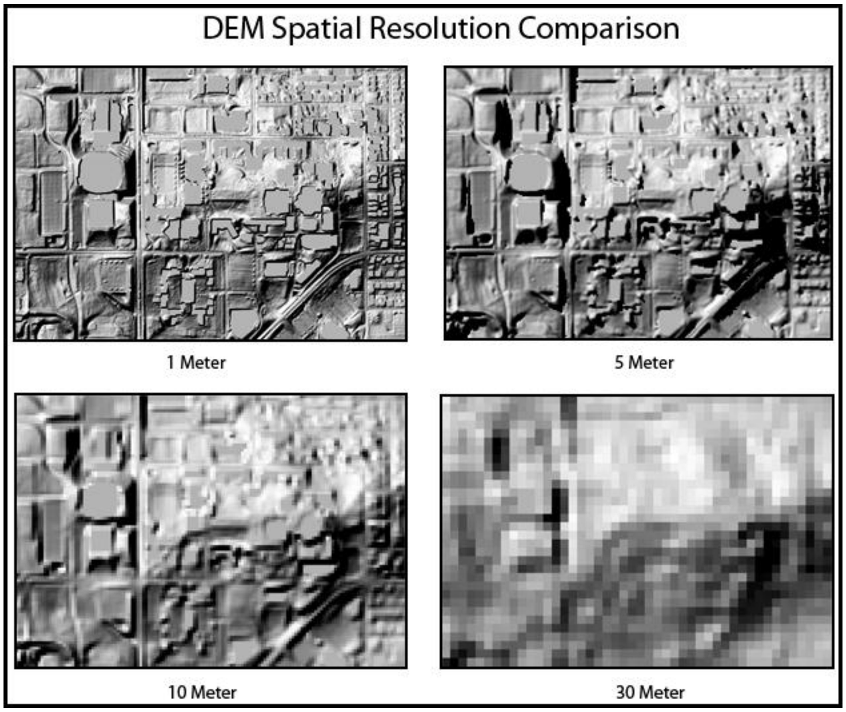

Figure 1: Comparison of DEM Spatial Resolution derived from LiDAR

Urban watersheds are complex structures that require sophisticated modeling to estimate runoff and pollutant loads. There are many urban storm water models available include MUSIC (Model for Urban Stormater Improvement Conceptualization) and P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds) (Elliot, Trowsdale 2007). The Source Loading and Management Model (SLAMM) has been in existence since the late 1970s with constant updates and improvements with the purpose of modeling common small rainfalls (Pitt 2002). Many other urban storm water models are used to model heavy, less frequent rainfall. SLAMM was created to address some of the weaknesses of other models. Models such as MUSIC create drainage systems as well using links and nodes (Elliott, Trowsdale 2007). SLAMM estimates runoff and pollutant loads from areas with unique soil/land use combinations and lumps them by catchment area without drainage models because assumptions with the design of drainage systems are not appropriate for water quality models (Pitt 2002). SLAMM has been expanded to include a wide variety of source area and outfall control practices including: Infiltration practices, wet detention ponds, porous pavement, street cleaning, catchbasin cleaning, and grass swales (Pitt 2002).

The first objective of the project is to *investigate the effect of spatial resolution for urban storm water modeling.* The second objective is *to derive precise topographic representation from LiDAR elevation data and high resolution remote sensing data and to incorporate those data into WinSLAMM to predict sediment and phosphorous runoff from an urban watershed*. The study area is the University of Northern Iowa's Campus located in

Cedar Falls, Iowa (Fig 1). The University of Northern Iowa resides within the Dry Run Creek Watershed. The size of campus is 912 acres consisting of buildings, impervious surfaces, pervious landscapes, and waterways.

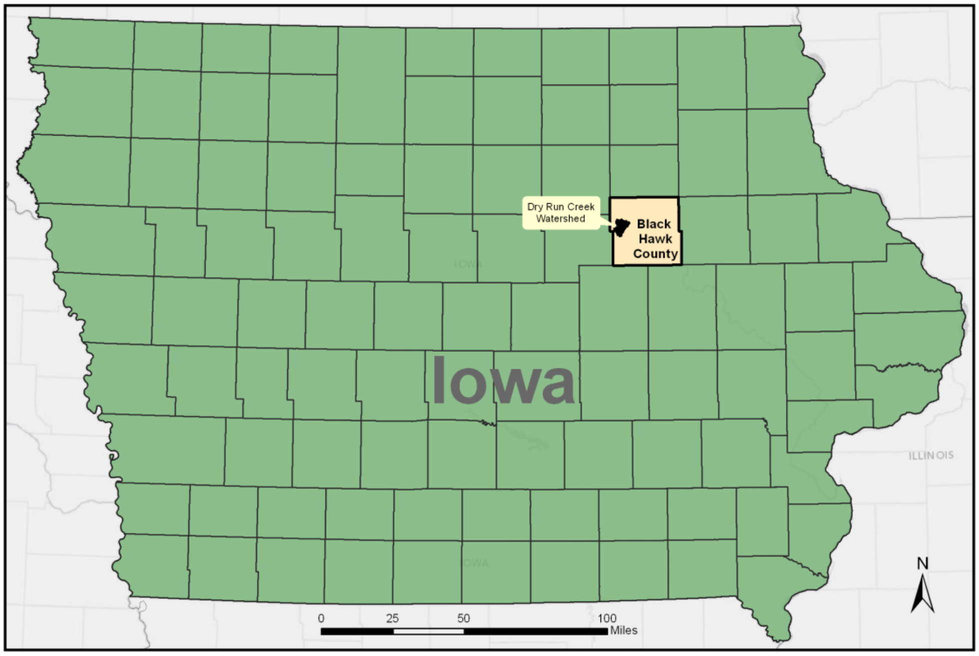

Figure 2: Study Area

Methodology

Figure 3 demonstrates the overall process and which were used to effectively utilize LiDAR data for WinSLAMM modeling of runoff and pollutant loads. The LiDAR data was processed using ESRI's ArcGIS for Desktop Advanced. The process consisted of converting the 46 ASCII bare earth tiles into multipoint feature classes that could then be added to a terrain network and converted to a raster which is the final DEM. The DEM was then edited to fix the topography of areas that created "digital dams." These digital dams are locations where water could flows through in the real world, such as underpasses or culverts, but which LiDAR was not able to accurately capture. A detailed and accurate stream network was used and slightly altered to match and was then "burned" into the DEM to force water to flow as it would naturally.

The remainder of the analysis consisted of utilizing the tools found available within ArcHydro, a hydrological modeling extension for ArcGIS. Tools used included Flow Direction which derives the direction of where the water would flow from any given cell. This is an important tool that is used to remove areas where water would puddle in. Once the DEM is completed, the Flow Accumulator can be used to set criteria that can be used to select pixels that other pixels flow into. These pixels are then extracted which make up streams and are used to extract sub-basins, which are used in WinSLAMM.

The delineated sub-basins were then used to split a feature class that contains detailed representation of land use/cover collected through field work (Table 1). This information is imperative for WinSLAMM to operate. The features were split to show all the land use/cover features that exist within each sub-basin. The areas of each sub-basin's features were then aggregated together for easier user input. The features were then manually entered into WinSLAMM and the total sediment and phosphorus loadings were recorded for each sub-basin.

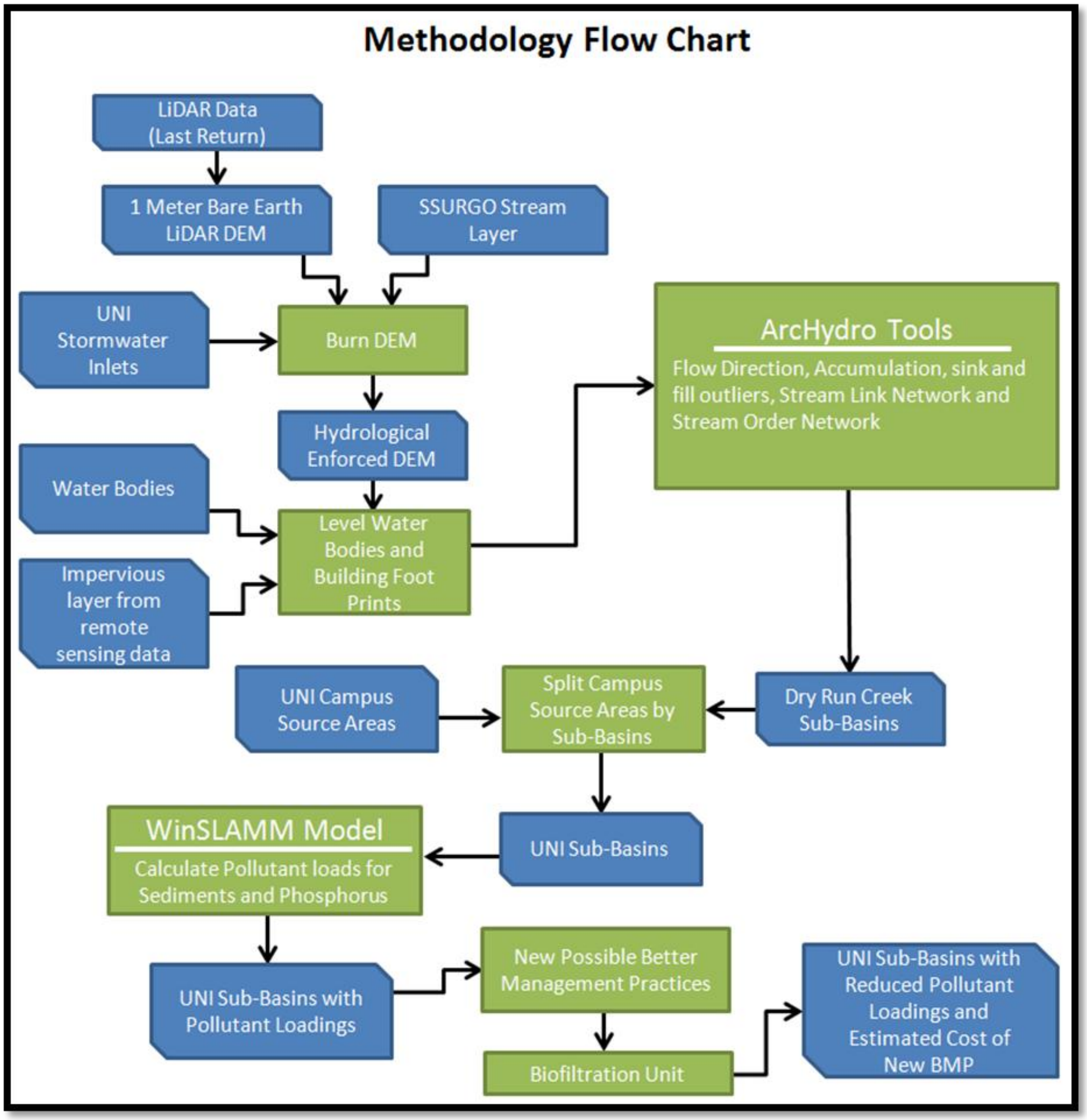

Figure 3: Methodology Flow Chart

Table 1: Feature descriptions gathered through field work

Feature	Drainage	Paved/Unpaved	RoofType	Landuse
Driveway	Connected/ Disconnected	Paved/Unpaved	NA	Institutional/ Industrial
Landscape	NA	NA	NA	Institutional/ Industrial
Other Impervious	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Other Pervious	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Parking	Connected/ Disconnected	Paved/Unpaved	NA	Institutional/ Industrial
Road	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Roof	Connected/ Disconnected	NA	Pitched/ Flat	Institutional/ Industrial
Sidewalk	NA	NA	NA	Institutional/ Industrial
Water	NA	NA	NA	Institutional/ Industrial

Objective 1: Determine the best spatial resolution for urban storm water management. After the DEM was created through LiDAR processing, it was then resampled from 1 meter into 5, 10, and 30 meter resolution DEMs. The process of delineating sub-basins was then redone for each new DEM and the results were presented based on the total number of sub-basins as well as the average size. *Objective 2: derive accurate spatial data from LiDAR elevation data and high resolution remote sensing and to incorporate data into WinSLAMM*. After the sub-basins were created, they were used to extract UNI campus source areas from a shapefile which was built by gathering data through field work. Once all the features were extracted based on the sub-basin, a printout was created through a Python script that accumulated the total area of unique land features within

the sub-basin . These values were used to parameterize WinSLAMM which was used to calculate runoff and pollutant loadings by each sub-basin.

Principal Findings and Significance

The first objective was to evaluate the most efficient spatial resolution to determine sub-basins. Four DEMs were created based on 1, 5, 10, and 30 m resolution DEMs (Figure 3). For each sub-basin the threshold used to delineate was 500 cells. This user defined threshold defines downstream cells which accumulate flow from at least the threshold (in this case 500) number of cells. By doing this a series of streams is created based on the DEM. There is a wide range of variability with selecting a threshold (Jenson 1991; Wang 1998; Da Ros 1997). A smaller threshold will result in a very detailed stream network while a large threshold will produce a stream network consisting of the main large, pronounced streams. The 1 Meter DEM was selected and used through the rest of the project with 78 sub-basins within the study area (Table 2). This is because the 1 m DEM allows the derivation of detailed sub-catchment boundaries which allow for more precise WinSLAMM modeling.

Table 2: DEM Comparative Output

Digital Elevation Model	1 Meter	5 Meter	10 Meter	30 Meter
Cell Threshold	500			
Sub-Basins	741	268	67	11
Average Area of Cell Size (Acre)	20.27	56.2	225.02	1371.98

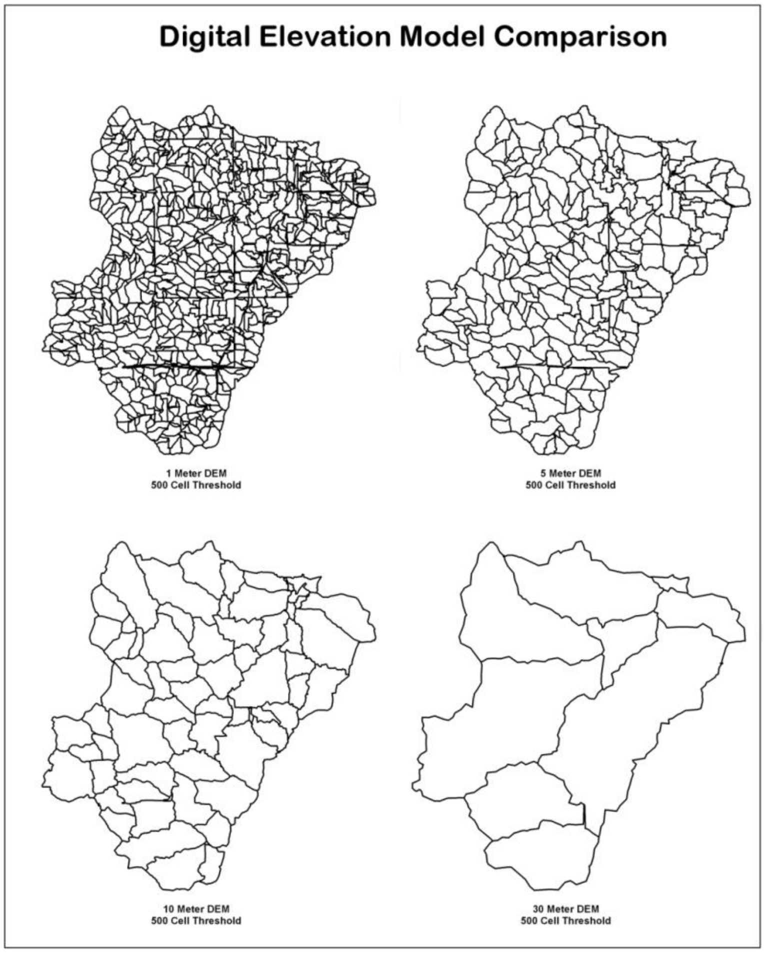

Figure 4: Comparison: 1, 5, 10, 30 Meter DEM

The results of the WinSLAMM modeling demonstrate heterogeneity in estimated levels of pollutants being discharged. The sediment load results (Figure 4A) show the amount of sediments that are predicted to be runoff from each sub-basin. The areas with the highest amount of runoff are within the areas with the highest amount of impervious surfaces. Areas in the southwest of the study area consist mostly of large undeveloped landscapes which are highly pervious resulting in a low predicted pollutant discharge. Central and northern sections consist of many impervious surfaces with small landscapes. These areas also contain high traffic due to parking lots. Areas in the Northeastern section of the study area contain large amounts of clay soil which can negatively contribute to the sediment discharge into waterways.

Also shown are the results from the phosphorus pollutant loads (Figure 4B) estimation. These results show similarities to the sediment loadings as well as high results near the southwestern industrial areas in the study area. The central and northwestern areas consist of maintained landscapes which can contribute to phosphorus loadings due to fertilization which WinSLAMM generates based on the land use classification.

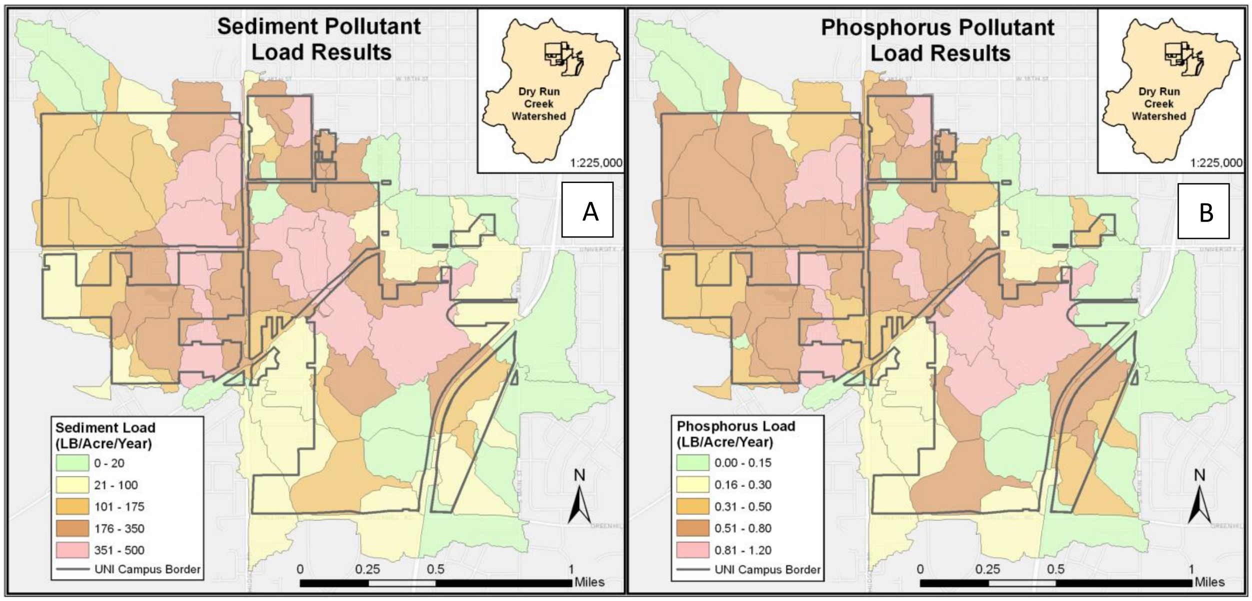

Figure 5: Pollutant Loading Results. A: Sediment Loads. B: Phosphorus Loads.

Five sub-basins were selected from the results based on their phosphorus and sediment outputs as well as available areas within each sub-basin that would have space to implement a biofiltration unit. WinSLAMM modeling scenarios were then carried out based on introduction of these biofiltration units. Each of these sub-basins contains a large amount of impervious surfaces which greatly contribute to the amount of pollutant output. Every sub-basin selected contains grass areas that allow infiltration to take place. The goal is to locate a BMP within a pervious surface that the impervious surfaces will drain into. Shown below are the impervious and pervious surfaces that are within each sub-basin (Figure 6). By locating a BMP within a pervious surface, the runoff from the impervious surfaces will greatly increase the rate of infiltration and reduce the amount of runoff that currently occurs.

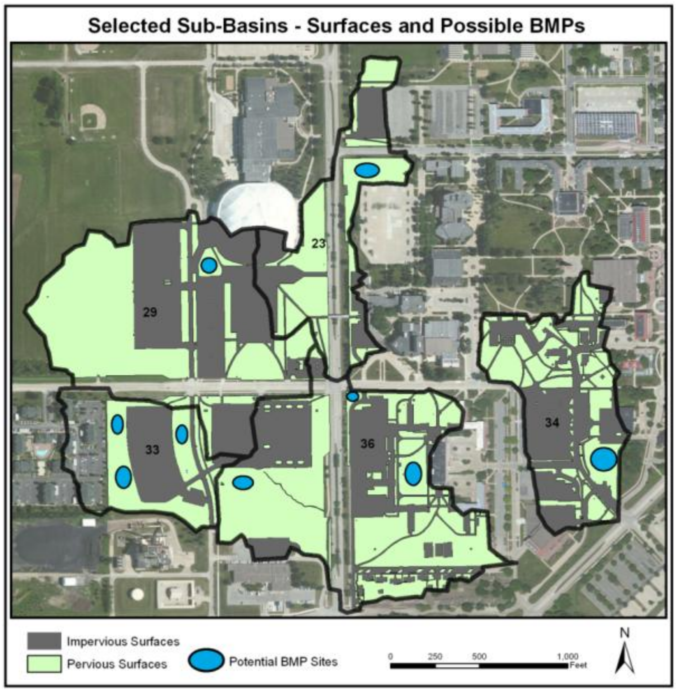

Figure 6: Selected Sub-Basins for BMPs.

The potential BMP sites were located near large areas of impervious surfaces so that the majority of the runoff from these sites could be channeled into the BMP. Not all the sites shown (Figure 6) will contain a BMP but these sites were determined to be the most optimal location within these sub-basins. Detailed information regarding the expected biofiltration units were input into WinSLAMM. Shown below are the specifications of what each BMP will consist of including an expected size, depth, and engineered soil (Table 3).

As you can see many of the biofiltration units do not deviate from a standard structure. Current BMPs on UNI campus follow a similar structure which has been found effective. The only changing variable is the size of the unit itself which is based on the amount of room available and is a major factor in the amount of runoff that will be drained within the BMP. For example, sub-basin 34 contains a large amount of impervious surfaces without much pervious areas so it would require a larger BMP to allow more infiltration to occur. The biofiltration unit also consists of the vertical stand pipe and a broad crested weir for flood control.

Table 3: Expected Biofiltration Cell Details

Sub-Basin BMP	Top Area (sf)	Bottom Area (sf)	Total Depth (ft)	Rock Filled Depth (ft)	Rock Porosity (0-1)	Engineered Soil Infiltration Rate (in/hr)	Engineered Soil Depth (ft)	Engineered Soil Porosity (0-1)	Underdrain, Vertical Stand Pipe, Broad

									Crested Weir
23	7156	7156	8	2	.75	2.5	5	.39	Yes
29	4073	4073	8	2	.75	2.5	5	.39	Yes
33	18621	18621	8	2	.75	2.5	5	.39	Yes
34	24406	24406	10	3.5	.75	2.5	5	.39	Yes
36	16727	16727	9	2	.75	2.5	5.5	.39	Yes

The proposed BMPs were incorporated in WinSLAMM model scenarios and were compared to the previous results without the BMPs. Table 4 shows runoff reductions in both sediment and phosphorus loadings. These biofiltration cells are designed to collect water and allow slow infiltration which would reduce the amount of runoff. The results show large reductions after implementing the biofiltration BMPs. The most significant reductions were in sub-basins 34 and 36. Sub-basin 34 shows the highest reduction amount of total phosphorus loadings with a reduction of approximately 75%.

Table 4: SLAMM Results with Potential BMPs

Sub-Basin	Prior to BMP			After BMP			
	Runoff Volume (cu ft)	Total Pollutant Loading (lbs)	Total Phosphorus Loading (lbs)	Runoff Volume (cu ft)	Percent Runoff Reduction	Total Pollutant Loading (lbs)	Total Phosphorus Loading (lbs)
23	396285	4008	0.2953	152901	61%	1936	4.548
29	1162000	12887	24.5	742865	36%	8459	16.01
33	334269	5233	12.05	71687	79%	1400	3.335
34	5199696	6399	11.59	96689	81%	1388	2.862
36	889441	10648	22	127129	86%	2076	5.057

The goal of this project was to determine if GIS and a LiDAR-derived DEM could produce a more efficient WinSLAMM model. In theory utilizing a DEM with a higher spatial resolution should be effective in modeling the flow of water on the surface. In this project the LiDAR-derived DEM was used to successfully extract the sub-basins within Dry Run Creek through the tools available within ArcGIS and freely available extensions. Within this project it was determined that 1 meter DEM was more efficient to extract sub-basins. However, it would also be suitable to use the 5 meter DEM. The 5 meter was simply more generalized than the 1 meter DEM.

The proposed BMP sites were effective in reducing the amount of pollutants as well as total runoff from entering waterways. These results are modeled estimates and are not to be considered actual amounts. The results are realistic; however the cost of creating the BMP may not be economically feasible. This process of determining pollutant runoff requires a large amount of knowledge of the study area and all the features within it. WinSLAMM can operate without more limited data but will be able to process more realistically the more data available.

Storm water modeling software provides users with estimates of pollutant loadings being discharged from a given area based on multiple criteria. WinSLAMM gives outputs that can be considered reliable based on their multiple decades of research and data verification. Together with the powerful capabilities of GIS, as well as the temporal and high spatial resolution of LiDAR, a more effective WinSLAMM model can be created.

The first objective of this paper shows that high spatial resolution DEMs can be effectively used to determine urban watersheds. This project reports that the most optimal resolution is between 1 and 5 meters which show very similar results. The 1 meter DEM did require more processing to remove errors such as sinks. Compared to common models which use 10 to 30 meter DEMs, the results shown in this project allowed a higher level of detail to be conveyed which is important within a constantly varying environment such as in urban areas. WinSLAMM was effective in modeling potential urban runoff due to its ability to estimate data based on land use classifications. Combined with the high spatial resolution DEMs, it was possible to determine very accurate urban runoffs. WinSLAMM's primary use is for urban planning but it can be an effective way of estimating runoff and pollutant loads from large areas without requiring a large amount of effort in collecting and measuring data through fieldwork.

The future goal of this project is to automate pre- and post-processing of WinSLAMM inputs and outputs through a free extension entitled "ArcSLAMM." This extension will make the entire process undertaken thus far in this project more efficient through a coupling of ArcGIS, databases, and WinSLAMM.

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Quantifying Field Water Balance Components as Affected by Shifts in Land-Use Patterns: Implications for Minimizing Agricultural Impacts on Water Quality in Iowa

Basic Information

Title:	Quantifying Field Water Balance Components as Affected by Shifts in Land-Use Patterns: Implications for Minimizing Agricultural Impacts on Water Quality in Iowa
Project Number:	2012IA194B
Start Date:	3/1/2012
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	Iowa 004
Research Category:	Water Quality
Focus Category:	Water Use, Water Quality, Water Quantity
Descriptors:	
Principal Investigators:	Robert Horton, Matthew J. Helmers

Publications

There are no publications.

Progress Report Submitted to the Iowa Water Center

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Focus Categories: Water Use, Water Quality, Water Quantity

Research Category: Soil Hydrology

Keywords: Water Quality, Crop Water Use, Evapotranspiration, Biofuels, Hydrologic Model, Land-use change

Duration of Project: 3/1/2012 – 2/28/2014

Congressional District: Iowa 4

Abstract

Increasing energy demands, global warming and concerns about fossil fuel depletion has led to an increasing focus being placed on bioenergy crops in the US. Large scale land-use changes from a corn-soybean rotation to native perennial plants have the potential to significantly alter the regional water balance and nutrient dynamics in the Midwest region of the US. Since nutrient loads in the surface water bodies remain a major environmental problem in Iowa today, it is vital to understand how the shift in land-use patterns can affect the regional hydrological cycle and change nutrient transport processes. In earlier research carried out by the PI and collaborators at the Comparison of Biofuel Systems (COBS) research site near Ames, IA, significant differences were observed in the drainage volumes and drainage water quality parameters among different biofuel cropping systems. The mechanisms driving these differences remain largely unknown. Crop evapotranspiration (ET) is a dominant factor in water balance of any region, but data are not available for direct field measurements of ET for some field crops, especially for a mixed prairie stand. There is a need to quantify ET by direct field measurements to help quantify the regional hydrological cycles. It is also important to quantify how changes in cropping systems affect the regional patterns in order to improve the management of regional water quality problems. The goal of the proposed work is to quantify the field water balance components as affected by different biofuel cropping systems. Direct field measurements of ET by a chamber technique and by sap flow measurements coupled with soil moisture, drainage and water quality data will enable us to measure crop water use under different cropping systems. This will also help us to quantify the dominant components leading to differences in drainage volumes among different cropping systems. The data obtained will be used to evaluate a crop growth, hydrological, and water quality model (RZWQM) to provide a tool for investigating the implications of land-use changes on field, state, and regional hydrological scales under a variety of soil, climatic and cropping conditions.

Statement of Regional or State water problem:

Increasing energy demands and concerns about climate change and fossil fuel depletion has led to an interest in alternative energy systems (Graham et al., 2007). To meet the Energy Independence and Security Act (EISA) 2007 mandate of 56.8 billion liters of ethanol annually from 2022 (U.S. Department of Energy, 2008), large areas of land will need to be shifted from row-crop food-grain production to bioenergy production systems in the Midwest. However, use of food grains for bioenergy production will lead to competing uses of grain, leading to higher food prices. A resulting increase in area under row-crops and more intensive management can lead to environmental concerns such as soil erosion, soil health decline and increases in nutrient loads in surface waters, thus further impairing water quality in Iowa and the upper Midwest. Another alternative is to use crop residues for lignocellulostic biofuel production systems, but removal of residue from the surface can have adverse effects on soil physical properties such as decreasing infiltration rates due to surface sealing and consolidation by rain drops, leading to a decline in plant available water (Canqui et al., 2007), increases in runoff, soil erosion and nutrient loads in the surface waters. Residue removal will negatively affect soil health in the state of Iowa, resulting in higher fertilizer use, declines in soil organic carbon, crop yields and microbial activity, increases in production costs and a further impairment of water resources of the region (Lal, 2005, 2007: Wilhelm et al., 2004).

Iowa's agriculture economy depends on intensive, high input row-crop systems, but intensive management and high fertilizer use in Iowa fields has led to deterioration in water quality and high nutrient loads in the state's surface waters. Despite huge efforts by scientists, farmers and state and federal governments, Iowa fields continue to be a leading source (~20%) of nitrogen in the Mississippi river, responsible for formation of a hypoxic zone in the Gulf of Mexico. The increase in public concern over this problem and potential new regulations will demand a significant reduction in nutrient loads in the streams of Iowa and the Upper Midwest. In this scenario, perennial vegetation such as native prairie species can offer a great possibility as an alternative bioenergy source. Potential benefits of using these native perennial plants as a bioenergy crop include economic gains such as lower farm inputs and reduced management, possibility to use marginal lands, and multiple short and long term environmental advantages.

Production of the biofuel crops may need to occur on large concentrated zones around the biofuel processing units rather than individual small areas in order to maximize profitability and minimize transportation. The resulting shift in land-use over large areas coupled with climate change patterns that Iowa will likely face in the future will significantly alter the hydrology of the region and the nutrient dynamics in Iowa and the Upper Midwest region. Therefore, it is vital to understand how the shift in land-use patterns can affect the regional hydrological cycle and a resulting change in nutrient transport processes.

Previous research by the PI and collaborators suggests that landscape conversion to perennial vegetation can have significant effects on drainage patterns and water quality on a field scale. Work at the Comparison of Biofuel Systems (COBS) research site near Ames, IA during the growing seasons of 2010 and 2011 (Figure 1) shows relatively small subsurface drainage volumes for prairie systems compared to annual crops. Such differences have the potential to alter soil water storage and water quantity export patterns that could ultimately impact stream-flow both positively and negatively depending on the timing of the changes. Differences in peak load of water volume will affect the nutrient flow from the fields, resulting in lower water and nutrient flow rates from the perennial crop systems. A majority of the soil erosion in Iowa occurs during the spring season due to large volumes of runoff owing to spring rains, snow melt and little or no crop cover. The early development of canopy in the prairie may serve as a protective cover, shielding the vulnerable soil from erosion by reducing the rain-drop impact. Improved soil structure and higher root-density of prairie in the spring will enhance infiltration rates, thus reducing runoff and increasing soil water content, resulting in lower sediment losses and improved downstream water quality.

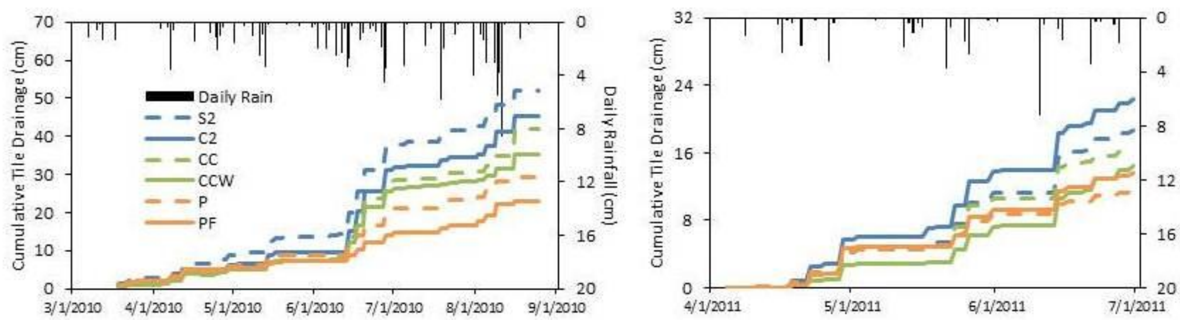

Figure 1. COBS cropping system drainage water quantities observed in 2010 and 2011. S2 is soybean following corn, C2 is corn following soybean, CC is continuous corn, CCW is corn with a cover crop, P is unfertilized prairie, and PF is fertilized prairie.

On the other hand, conversion of row crop agricultural land to prairie systems may increase plant water use and deplete soil water during the summer growing season. The depletion of soil water will impact soil nutrient cycles, microbial activity and soil nutrient transformations. Prairie systems begin transpiring water earlier in the spring and continue later in the fall than corn and soybean systems due to prairies having greater biomass during these periods. Changes in water loss as evapotranspiration (ET) and differences in crop canopy cover can alter the surface energy balance, thus changing the amount of net energy available for warming up the soil, again affecting soil microbial activity and nutrient dynamics of the soil.

The water quality and nutrient contamination in surface waters depends on the drainage volume from the field as well as the timing of drainage but the mechanisms responsible for these differences remain largely unknown. Crop evapotranspiration (ET) is a dominant component in the water balance of any region. Significant differences might exist for ET among annual and perennial cropping systems due to variations in crop canopy cover, root growth patterns, leaf area index, length of growing season and water use efficiency. Traditionally, ET is calculated from the difference in all water gains and losses in a soil system, when all other components of water balance are quantitatively determined. The ET values determined by this technique are subject to error, as the measurement errors in all other water balance components get lumped together in the ET values. Direct field level measurement data for ET of field crops are not available, especially for a mixed prairie stand.

The goal of the proposed work is to better understand and quantify the field water balance components as affected by different biofuel cropping systems. Direct measurements of ET will be used to calibrate and validate the Root zone Water Quality Model (RZWQM) for predicting water quantity and quality patterns among different cropping systems. RZWQM is a one – dimensional (vertical soil profile) model that simulates the effect of climatic patterns, soil types, crop-rotations and management practices on plant growth, water movement through soil profile and water quality applications such as movement of nitrate and pesticides to runoff and tile drainage. (Malone et al., 2001, Ahuja et al, 2000). This model has been used extensively for water quality projects in the Midwest (Watts et al, 1999, Qi et al., 2011).

Statement of results/benefits:

This research will provide vital understanding of how the change in cropping systems of the Midwest can lead to shifts in regional hydrology and nutrient export patterns from Iowa fields. Direct field measurements of ET will improve our understanding of crop water use under different cropping systems. This will also provide valuable crop water use and crop coefficients information for predicting future crop water requirements, soil water storage and drainage components as affected by the potential future changes in Midwest cropping patterns. The proposed research will provide understanding of the differences in drainage volumes among different cropping systems. The data obtained will be used to evaluate a drainage and water quality model (RZWQM) to provide a tool for understanding the implications of land-use changes on a regional scale under a variety of soil, climatic and cropping conditions. The model will be used to guide policy-making decisions for optimizing production of biofuel crops in Iowa and the upper Midwest.

Nature, scope and objectives of the Project:

The Comparison of Biofuel Systems (COBS) research site near Ames, Iowa will be the field study site. At COBS, cropping systems include reconstructed mixed prairie stands with and without N fertilization, continuous corn with and without winter rye cover crops, and corn-soybean and soybean–corn rotations, thus representing present and potential future cropping systems in Iowa and the Midwest. Biomass for biofuel production is harvested annually from all prairie and corn plots. The prairie was established in the spring of 2007, using a seed mixture of different prairie species representing the natural perennial vegetation in the region. The field study site includes 4 replications for each of the 6 treatments in a randomized complete block design. The study site is tile drained and facilities exist for monitoring and sampling drainage water flow independently for each plot. A weather station at the study site records weather data. A favorable point for this location is that much of the equipment and set-up required for the study is already in place, which reduces research expenses.

Scope:

The proposed work will help not only to quantify the water quality impacts of alternative cropping systems, but will also provide an insight into the mechanisms responsible for these changes. On the science side, the study will help in improving the ET measurements and evaluation of a novel closed chamber technique as a tool for quantification of plant transpiration. Improvement in the RZWQM will help to predict crop water use, soil water storage, drainage volumes and nutrient loads in drainage water for a range of selected crops, soils and climate conditions in order to predict potential effects of land use change on water quantity and quality in the region. Field data and the model will be used as a decision support tool for Iowa State

University research and extension personnel, Iowa Department of Natural Resources (Iowa DNR), the NRCS and related state and federal agencies. The proposed research work will be used to leverage additional funds from the USDA or the National Science Foundation (NSF).

Objectives:

1. To measure and contrast dynamic soil water storage, drainage and evapotranspiration in reconstructed mixed prairie and no-till corn and soybean cropping systems.
2. To understand the relation between field water balance components and off-site water quality impacts of alternative cropping systems and management strategies.
3. To use field data to evaluate and improve a crop hydrological and water quality model, and then use the model to predict implications of land use conversion on water quality and quantity for a variety of selected cropping systems, soils, and climatic conditions.

Timeline of activities:

During the growing season of 2012, field measurements of continuous soil moisture, drainage and ET from closed chambers will be complemented with soil sampling for determining seasonal trends in soil properties. Soil water storage in the root-zone will be monitored by time domain reflectometry (TDR) probes. Soil moisture sensors at 5 depths and soil sampling for laboratory analysis will be used to supplement data obtained from the TDR probes. Drainage water volume and quality will be monitored at the tile drain outlets. Actual evapotranspiration (ET_a) will be measured at strategic intervals using the closed chamber technique (see Methods for details). This information will be supplemented by sap flow measurements for transpiration in corn. Periodic soil sampling will be done for soil bulk density and gravimetric water content analysis to supplement the field sensor measurements. Complete water balance evaluation will be done to understand the dominant components responsible for differences in drainage volumes from the different cropping systems. Drainage water will be tile monitored for N and P concentrations to determine variations in water quality patterns among the different biofuel cropping systems. The data will also be used to calibrate the root zone water quality model (RZWQM).

The data collection will continue in the growing season of 2013. During the second year of study, the field data will be used to evaluate and improve RZWQM to understand drainage volumes and water quality from different cropping and management systems in the Midwest.

Methods, Procedures and Facilities

Chamber Design and Construction:

Portable, dynamic canopy chambers will be used to measure ET from the different cropping systems. The dynamic chamber approach was selected as the plots have insufficient fetch for eddy covariance or Bowen ratio energy balance techniques (Sauer et al., 1998; 2002; Hatfield et al., 2007; Hernandez-Ramirez, 2009). Dynamic chambers are also preferred over static, open chambers in order to avoid undesirable microclimate modifications (Garcia et al., 1990; Reicosky et al., 1990). The proposed chambers will be constructed of a welded aluminum frame with 0.127 mm-thick clear polyester mylar film covering, which has excellent radiation transmittance properties to minimize changes in the spectral characteristics of incoming global radiation (Krizek et al., 2005; Pérez-Priego et al., 2010). The chamber inside dimensions will be 1.52 x 1.52 x 1m (l x w x h) to enclose an area (2.31 m^2) that will contain two crop rows in corn and soybean and approximately 8 and 40 individual plants, respectively. To improve measurement accuracy, the mylar side panels will be segmented and the top section adjustable to reduce the chamber volume from 2.8 m^3 (1 m tall) to 0.69 m^3 (0.3 m tall) for flux measurements over bare soil and until the plant canopies reach a height of 0.3 m. The base of the chamber will be covered with rubber inner tube filled with flexible padding to conform to uneven soil surfaces and prevent any air leakage during flux measurements. Some smoothing of the soil surface may be necessary to assure good, leak-free contact between the chamber base and soil surface.

One of the innovative features of these chambers will be the use of a LI-COR LI-7500 Open Path CO_2/H_20 Analyzer located within the chamber to quantify changes in H_20 vapor concentration in the chamber air space during measurements. The LI-7500 will have a coarse mesh guard to prevent plant leaves from crossing the optical path. Use of the sensitive, fast-response LI-7500 avoids several concerns/errors associated with collecting a representative air sample inside the chamber and pumping it through a closed-path infrared gas analyzer (Reicosky et al., 1990; Pérez-Priego et al., 2010).

Sampling Protocol and Data Analysis:

Two chambers will be built to allow simultaneous measurements in two treatments. The chambers will be manually placed in position for the minimum amount of time to collect accurate flux measurements (60-90 sec) and then removed to minimize chamber effects on light, wind speed, and air/leaf temperature. This approach allows repeated measurements at multiple locations within the plot area at desired intervals that can be strategically adjusted based on ambient environmental conditions or agronomic operations. Measurement locations will be selected to be representative of the treatment. Chamber measurements will be made at selected times from spring thaw until fall. On selected days, measurements will be made on each treatment to determine the maximum ET for the ambient conditions. Once a month hourly measurements will be made during daytime hours on one replicate of each treatment to discern diurnal ET patterns. Chamber measurements will be used to validate RZWQM for the selected days. RZWQM will then be used to estimate daily ET for the year.

The concentration regression method will be used to calculate ET from the changes in H_2O vapor concentration vs. time (dw/dt in mmol mol^{-1} s^{-1} for H_2O vapor) after chamber closure (Reicosky et al., 1990; Steduto et al., 2002):

$$ET = \frac{dw}{dt}\frac{V}{S}\frac{P_a}{RT} \qquad (1)$$

Where V is the chamber volume (m^3), S is the chamber areal footprint (m^2), Pa is the atmospheric pressure inside the chamber (kPa), R is the universal gas constant (8.3×10^{-3} m^3 kPa mol^{-1} K^{-1}), and T is the air temperature in the chamber (K).

Several measurements in addition to changes in H_2O vapor concentration are necessary to test and monitor chamber performance by characterizing the effect of the chambers on canopy microclimate (Steduto et al., 2002; Burkart et al., 2007). Each chamber will have within it an air temperature/relative humidity probe to track air temperature and vapor pressure deficit, an infrared thermometer to measure leaf/soil temperature, a photosynthetically active radiation (PAR) sensor to measure the light characteristics, and a differential pressure transducer to measure the difference in air pressure between the chamber and atmospheric pressure. After a chamber is placed on the soil and a measurement cycle begins, low-pressure, high-volume DC tube axial fans will engage to thoroughly mix the chamber air enabling accurate H_2O vapor concentration measurement by the LI-7500. These fans will induce a small negative pressure that needs to be monitored and minimized (< ~2 Pa) to avoid drawing H_2O vapor from the soil air space. A second infrared thermometer will be mounted on the outside of the chamber to detect leaf/soil temperature outside the chamber for comparison with the temperature inside the chamber, which also need to be minimized (< ~0.5°C increase). An on-site weather station will provide data on ambient air temperature and relative humidity, PAR, atmospheric pressure, wind speed and direction, and precipitation. The chamber sensors and control mechanisms and the weather station will all be logged and controlled by Campbell Scientific CR3000 dataloggers.

<u>Corn Sap Flow Measurement</u>**:**

After the corn canopy reaches 1 m height, chamber measurements will cease on all corn plots and sap flow measurements of individual corn plant transpiration (T) will commence. Sap flow stem gauges (Dynagage SGA5-WS Microsensors, Dynamax, Inc., Houston, TX) will be deployed on eight adjacent corn plants. All sensors will be connected to a Campbell Scientific CR10X data logger to record data every 15 minutes. All gauges will be moved to new plants every 10-14 days to avoid damage to the stalks and allow destructive sampling of each plant to determine the green leaf area index (LAI). All gauges are covered with foam insulation and aluminum foil to minimize temperature gradients. T will be calculated by multiplying the mean value of sap flow from the six plants by the plant density (Gerdes et al., 1994; Sauer et al., 2007) and converted to a depth of water per 15 min. interval. Soil water evaporation (E), although assumed to be small, will be measured using microlysimeters.

Related Research

Most related research has focused on field measurements of water quantity and/or water quality of annual row crops such as corn and soybean. A few studies have been performed on perennials such as switchgrass or prairie species. However, to our knowledge, no comprehensive tile-drained studies have been performed on the range of annual and perennial cropping systems considered in this proposed study. The COBS study site includes mono-culture annual crops (corn and soybean) and poly-culture perennial crops (mixed prairie). It includes high fertilizer input crops (corn) and low fertilizer input crops (unfertilized prairie). The study is unique in that each field plot has monitored tile drain lines to determine drainage quantity and drainage quality for the various cropping systems. The proposed study includes the development and use of chambers to measure ET directly in the various cropping systems. The combination of drainage measurements and ET measurements will provide a scientifically unique data set. The data will be invaluable for calibrating and validating a crop growth, hydrological, and water quality model. Having a uniquely calibrated model will enable us to perform larger scale studies in the future to evaluate spatial and temporal impacts of various cropping systems across the landscape.

Training potential:

The proposed research will serve as a training opportunity for 1 PhD level graduate research assistant. Two hourly undergraduate students will be employed for assistance with the measurements, and data analysis, leading to valuable field research experience for all of the students.

Once the field water balance and water quality measurements and preliminary model results are validated, a larger scope proposal will be prepared for submission to USDA or NSF.

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APPENDIX

YEAR 1 PROGRESS REPORT

During the 2012 crop growing season, field water balance measurements were made at the ISU COBS research site in central Iowa. A weather station at the COBS site recorded air temperature and humidity, radiation, wind speed, and precipitation. Measurements of soil water storage and drainage were made throughout the growing season in reconstructed mixed prairie and no-till corn and soybean cropping systems. Closed chambers were specially constructed to measure evapotranspiration rates in the reconstructed mixed prairie and soybean plots. The chamber measurements were made during the latter part of the growing season. Soil water storage was monitored by soil moisture sensors at 5 depths in each field plot. In addition to the soil moisture sensors, time domain reflectometry (TDR) probes were installed in each plot to measure soil profile water contents. Drainage water volume and quality were monitored in each plot at the tile drain outlets. Based on the measurements of rainfall, change in soil water storage, and drainage volume, the evapotranspiration for the cropping systems could be estimated by a simple water balance calculation. Unfortunately, our goal of measuring evapotranspiration rates directly, independent of water balance calculations, was only partially realized. We were unable to complete the construction and testing of our ET-chambers before the start of the growing season. Thus, we did not observe independent field ET fluxes for the entire season. However, we did construct, test, and use the ET-chambers in the latter part of the growing season. The chambers functioned well, and they are ready for use during the entire 2013 growing season.

The partial growing season data set from 2012 along with a full season data set to be collected in 2013 will be used to not only calibrate the root zone water quality model (RZWQM), but also to evaluate and utilize RZWQM for understanding water balance components such as drainage and evaporation fluxes and drainage water quality from various cropping and management systems.

The following figures (photos, drawings and data) depict some of the progress made in 2012:

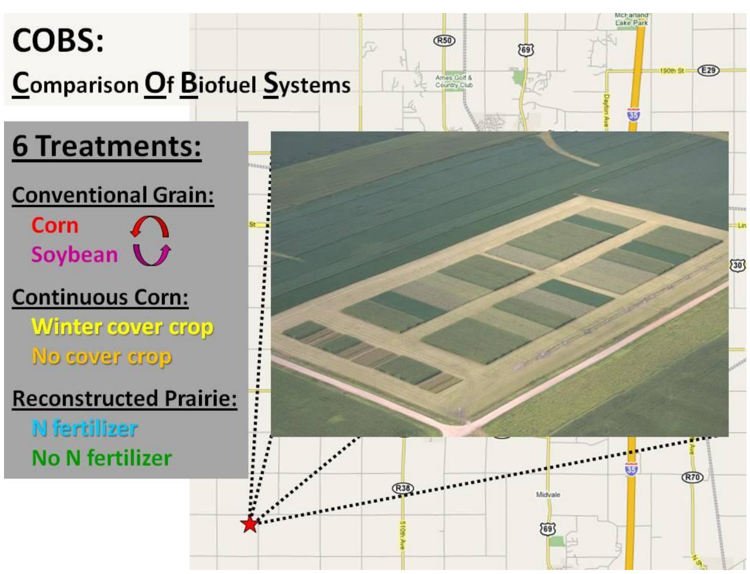

Figure 1. COBS field plots.

Figure 2. ET chamber being moved to field plots.

Figure 3. ET chamber in a prairie plot.

Figure 4. ET chamber in a soybean plot.

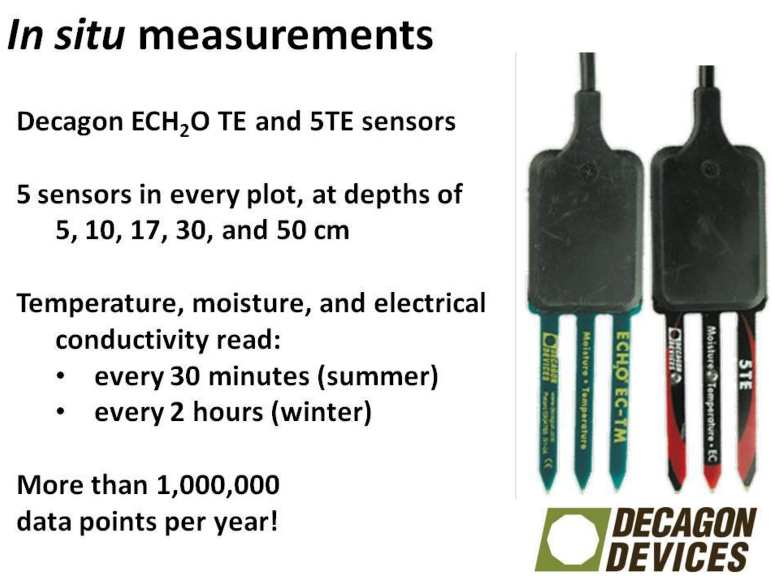

Figure 5. In situ soil moisture and temperature sensors.

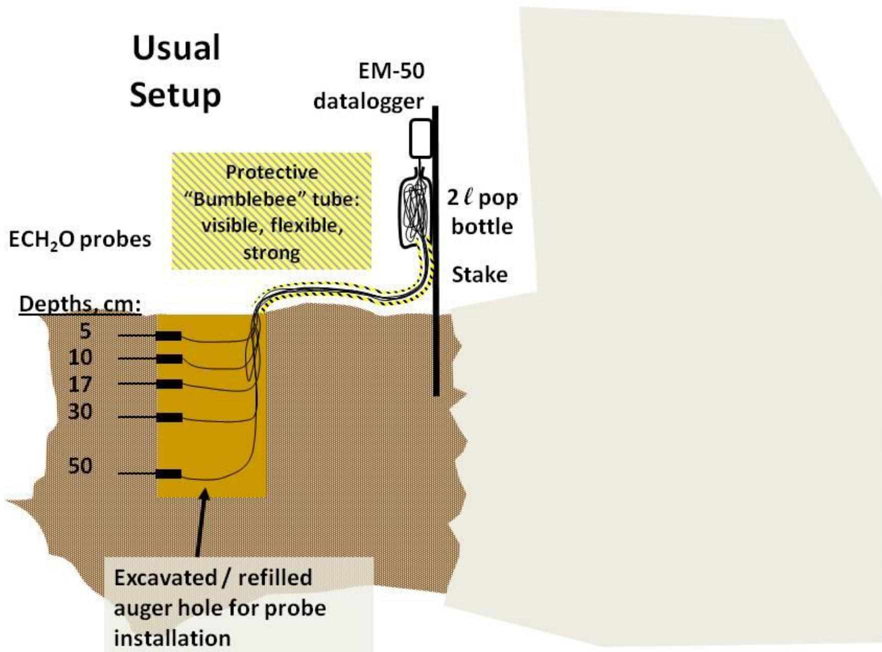

Figure 6. Installation depths of the soil moisture and temperature sensors.

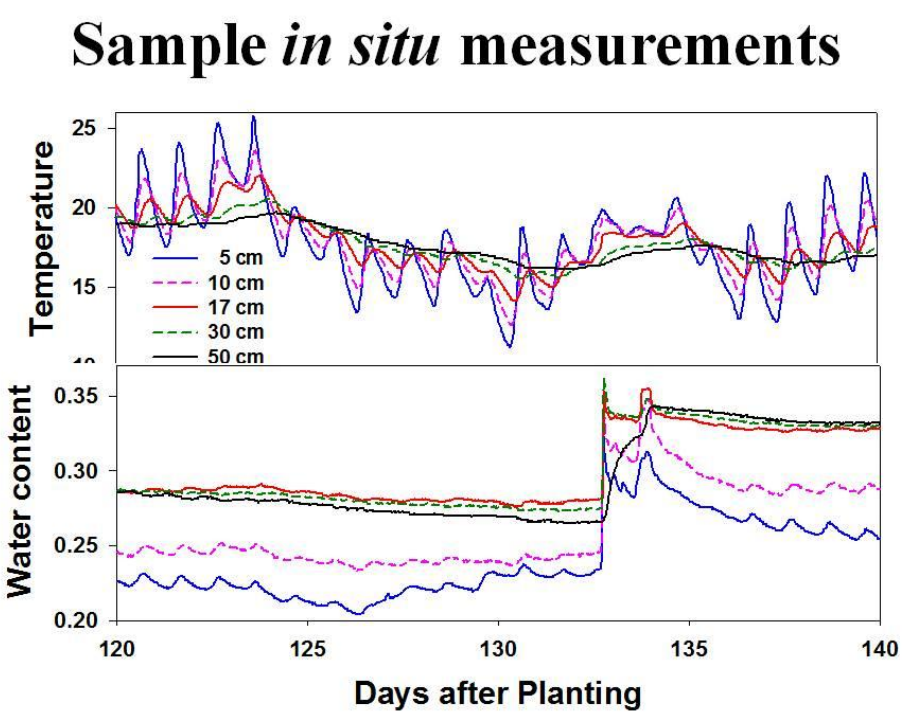

Figure 7. Sample of soil moisture and soil temperature data.

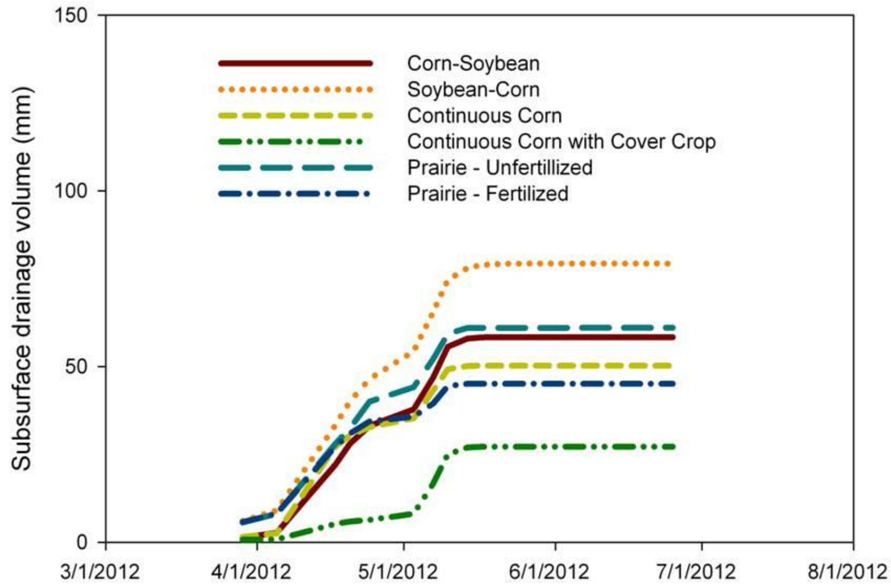

Figure 8. 2012 mean drainage volumes for various cropping systems.

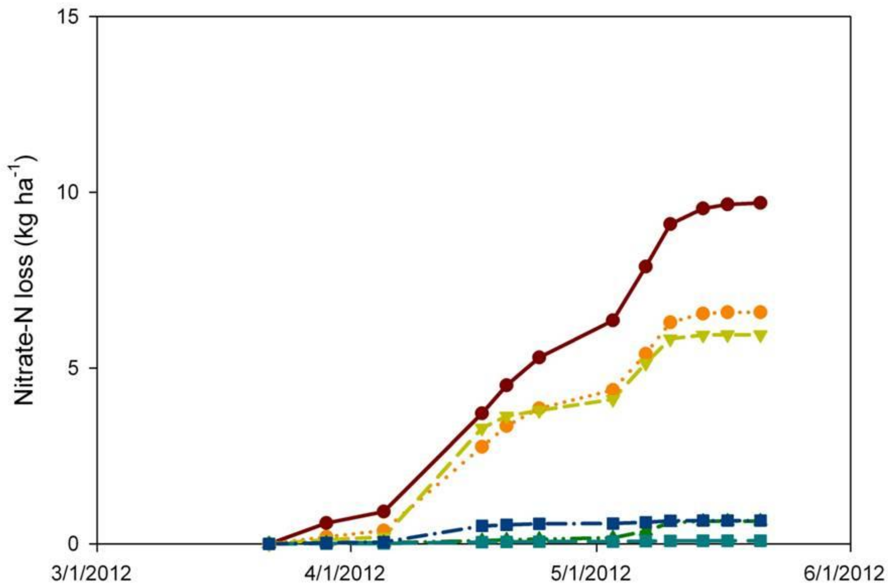

Figure 9. 2012 mean drainage nitrate losses for various cropping systems.

Dielectric Measurement of Soil Nitrate Concentration

Basic Information

Title:	Dielectric Measurement of Soil Nitrate Concentration
Project Number:	2012IA196B
Start Date:	3/5/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	Iowa 004
Research Category:	Water Quality
Focus Category:	Agriculture, Methods, Nitrate Contamination
Descriptors:	None
Principal Investigators:	Amy Kaleita

Publications

There are no publications.

1. **Principal Investigator(s):**

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2. **Focus Categories:** Floods, Hydrology, Models

3. **Research Category**: Hydrology

4. **Keywords:** depressional storage, MIKE SHE, LiDAR, monitoring

5. **Duration of Project:** March 1, 2012 – Feb. 28, 2013.

6. **Congressional District:** IA 4

7. **Abstract:**

Enclosed depressions in hydric landscapes of the Upper Midwestern United States play an important role in the hydrologic cycle of the region by providing storage during precipitation events. However, recent flooding in the region, and the potential for increased precipitation in the future due to climate change, have created a need for an improved understanding of the hydrologic role of depressional storage features and the influence of these features on downstream flow, particularly under high precipitation regimes.

Our **long term goal** is to understand the processes and factors affecting water and chemical fluxes and storages in urban and agricultural landscapes of the Upper Midwestern United States. The proposed research will help us address this goal by filling a critical gap in our ability to define and model key hydrologic processes operational in enclosed depressions and watersheds containing such features.

Our **goal for this project** is to study water fluxes associated with enclosed depressions in agricultural landscapes in order to improve our ability to predict their impact on downstream flow. We hypothesize that (i) enclosed depressional areas provide temporary hydrologic storage for small and moderate precipitation events, but minimal storage during chronic wet periods or large storm events; (ii) hydrological modeling systems can accurately capture water fluxes in singular depressions; and (iii) hydrological modeling systems can predict the impact of depressional storage on downstream flow.

We will test these research hypotheses by accomplishing the following series of tasks: (i) monitoring the frequency, duration and extent of ponding in two enclosed depressions in central Iowa with catchment areas that are primarily agricultural, (ii) using monitoring data and a hydrological modeling system such as MIKE SHE to predict storage dynamics of singular depressions, and in Year 2, pending continued funding, (iii) integrating LIDAR data with a hydrologic model MIKE SHE to predict downstream flow in watersheds with enclosed depressions in hydric soils, with particular emphasis on assessing the role of depressional storage on flood hydrology.

8. **Budget Breakdown**

Cost Category	Federal Funds requested	Non-Federal matching funds	Total
1. Salaries and Wages			
Engineering MS student	$20,640		$20,640
Principal Investigators		$29,217	$29,217
Total Salaries and Wages	$20,640	$29,217	$49,857
2. Fringe Benefits			
Engineering MS student	$2,663		$2,663
Principal Investigators		$8,707	$8,707
Total Fringe Benefits	$2,663	$8,707	$11,370
3. Supplies			
4. Equipment			
5. Services and Consultants			
6. Travel	$1,000		$1,000
7. Other direct costs	$5,737		$5,737
8. Total direct costs			
9a. Indirect costs on federal share	XXXXXXX	$11,656	$11,656
9b. Indirect costs on non-federal share	XXXXXXX	$18,203	$18,203
10. Total estimated costs	$30,040	$67,783	$97,823

9. **Budget Justification**

1. Salaries and Wages: Support is requested for 12 months of stipend for one engineering MS student (Provide estimated hours and the rate of compensation proposed for each individual ($1720 per month for 12 months, for a total of $20,640). Matching funds of one month of each of the three PI's is provided ($10,505, $8,934, and $9,778, for a total of $29,217).

2. Fringe Benefits: Fringe benefits are included for the graduate student at a rate of 12.9% ($2,663). Matching funds for faculty fringe benefits are included at a rate of 29.8% ($8,707).

3. Supplies: None requested.

4. Equipment: None requested.

5. Services or Consultants: None requested.

6. Travel: Funding for one person to attend and present at a national meeting are requested ($1000).

7. Other Direct Costs: Funding is requested for 50% of the engineering graduate student tuition for Summer 2012, Fall 2012, and Spring 2013 ($5,737).

8. Indirect Costs: Matching funds are included for unrecovered indirect costs at a rate of 48% on all budget elements except the graduate student tuition ($67,783).

10. Title: Modeling the impacts of depressional storage (potholes) on downstream hydrology under extreme climatic events.

11. Statement of regional or State water problem:

Enclosed depressions (potholes) in hydric landscapes of the Upper Midwestern United States play an important role in the hydrologic cycle of the region by providing storage during precipitation events. However, recent flooding in the region, and the potential for increased precipitation in the future due to climate change, have created a need for an improved understanding of the hydrologic role of depressional storage features and the influence of these features on downstream flow, particularly under high precipitation regimes. These depressional storage features are present in some of the most-heavily artificially drained land in the corn belt of the U.S. and these lands are a significant source of nitrate-nitrogen to downstream water bodies. Improved understanding of the hydrology of these landscapes is essential for improving our understanding of nutrient fluxes which will be critical for future land management choices to reduce downstream export of nitrate-nitrogen.

12. Statement of results or benefits:

MIKE SHE is a watershed-scale model widely used to predict surface hydrology. However, there is a need for further assessment of the model in poorly drained systems where artificial subsurface drainage is extensive. The model interfaces with ArcGIS and typically topographic data is developed from 10 or 30 meter digital elevation maps (DEMs). Topographic data are then used to delineate flow paths and simulate pollutant transport from land to surface waters. The monitoring data combined with the use of higher resolution topographic data, such as LIght Detection And Ranging (LiDAR, which will be explored specifically in Year 2 pending continued funding), which has a one meter resolution, will allow us to assess MIKE SHE's ability to predict water fluxes in singular depressions and improve our understanding of their impact on downstream flows. A hydrologic model capable of predicting the impact of enclosed depressions on downstream flows can also be used to predict pollutant delivery to streams, which is useful for the development of watershed management plans and to determine placement of conservations practices for improved water quality under a range of climatic events.

13. Nature, scope, and objectives of the project:

Our long term goal is to understand the processes and factors affecting water and chemical fluxes and storages in urban and agricultural landscapes of the Upper Midwestern United States. The proposed research will help us address this goal by filling a critical gap in our ability to define and model key hydrologic processes operational in enclosed depressions and watersheds containing such features.

We intend to use the results from this proposed study as preliminary data to support a larger proposal to the NSF Hydrologic Sciences Program. A brief overview of our long term goal and research plans was shared with program manage Richard Cuenca in 2009, who had a positive response but indicated the need for ‘proof of concept’ work in this area.

Our goal for this project, then, is to study surface and near-surface water fluxes associated with enclosed depressions in the Des Moines Lobe in order to improve our ability to predict their impact on downstream flow. We hypothesize that (i) enclosed depressional areas provide temporary hydrologic storage for small and moderate precipitation events, but minimal storage during chronic wet periods or large storm events; (ii) hydrological modeling systems can accurately capture water fluxes in singular depressions; and (iii) hydrological modeling systems can predict the impact of depressional storage on downstream flow.

We will test these research hypotheses by: (i) monitoring the frequency, duration and extent of ponding in two enclosed depressions in central Iowa with catchment areas that are primarily agricultural (spring, summer, and early fall 2011), (ii) using monitoring data and a hydrological modeling system (MIKE SHE) to predict storage dynamics of singular depressions (summer and fall 2011, spring 2012). In Year 2, pending continued funding, we will also (iii) integrate LIDAR data with MIKE SHE at the watershed scale to predict downstream flow in watersheds with enclosed depressions in hydric soils. The modeling effort will emphasize understanding the role of depressional storage on downstream flood flows. Both historical and simulated weather data will be used, to represent a variety of extreme event scenarios.

14. Methods, procedures, and facilities:

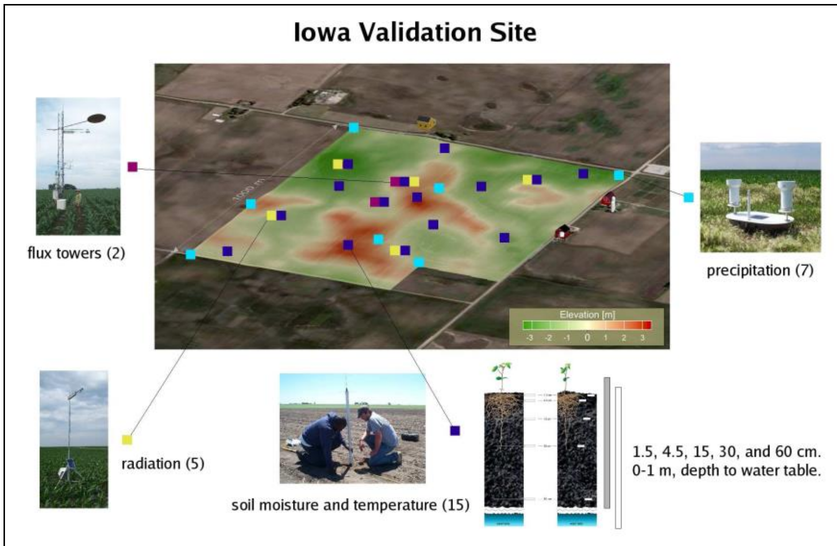

Figure 1. The Iowa Validation Site. Graphic courtesy of IVS PI Brian Hornbuckle (ISU Agronomy). In the aerial photo of the site, north is to the left side.

The Iowa Validation Site (IVS) is an approximately 1 km^2 agricultural field heavily instrumented with *in situ* sensors that measure multiple aspects of the terrestrial hydrologic cycle. It is currently funded by NASA Grant NNG06GC63G, 2006-2011, on which Dr. Kaleita is a co-PI. Observations include: soil moisture and temperature at 1.5, 4.5, 15, 30, and 60 cm at 15 sites; 4-component net radiation at 5 sites; and dual tipping-bucket rain gauges at 7 sites. Through cooperation with the USDA ARS National Laboratory for Agriculture and the Environment (NLAE), two flux towers which measure the fluxes of sensible and latent heat and carbon dioxide are available for estimation of evapotranspiration, and measurements of plant-available (0-1 m) soil moisture with a neutron probe as well as depth to the water table are made periodically. Detailed topography data (~1-3 m resolution) of the IVS is available from an on-site ATV-mounted GPS survey. These data, illustrated in Figure 1, are available as input parameters, driving variables, and corroborating data for the implementation and validation of MIKE SHE modeling of the site.

The field is farmed in a corn-soybean rotation. The site, while well instrumented, is not a "research field." It is owned and managed by Iowa State University, and farmed for income. In this way, it represents a fairly typical central Iowa farming operation. The field spans a boundary of the Walnut Creek Watershed, various hydrologic aspects of which have been extensively studied by other researchers at Iowa State and USDA ARS NLAE, and for which LiDAR data is readily available.

A collaborating colleague at the USDA ARS NLAE, Dr. Sally Logsdon, began documenting depth and extent of ponding at the two potholes at the IVS during the spring and summer of 2010. These potholes can be visualized in Figure 1 as the lower elevation regions at the northeast edge of the field and the southwest section near the 'notch.'

At each site, a surface "well" was inserted in or near the lowest point the depressional area, and instrumented with a pressure transducer that was read hourly. Preliminary data from the summer monitoring is shown in Figures 2 and 3.

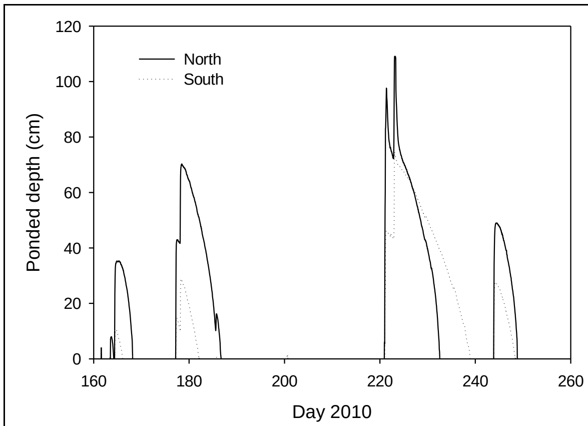

Figure 2. Estimated depth of ponding at two potholes at the IVS during the summer of 2010. Graph courtesy of Dr. Sally Logsdon

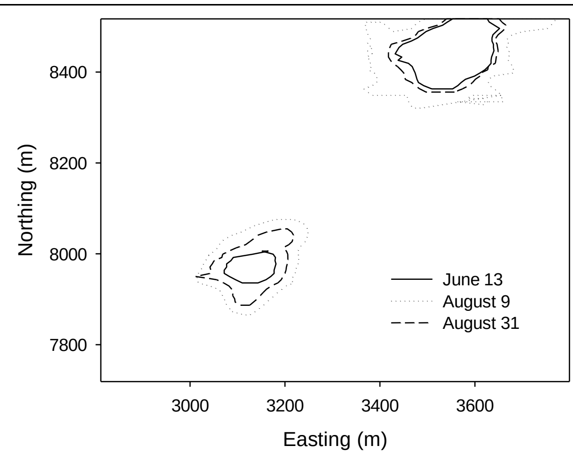

Figure 3. Estimated extent of ponded surface of two potholes at the IVS at points at three days within different summer 2010 ponding events. Graph courtesy of Dr. Sally Logsdon.

We will collect similar data for spring, summer, and fall of 2012, ensuring three years of observed pothole behavior. With this data, we will be able to characterize the extent and duration of ponding and quantify the change in depressional storage, with respect to various precipitation events. Since 2010 was a very wet year in central Iowa, we are ensured of having at least one season with significant pothole inundation to use in our analysis

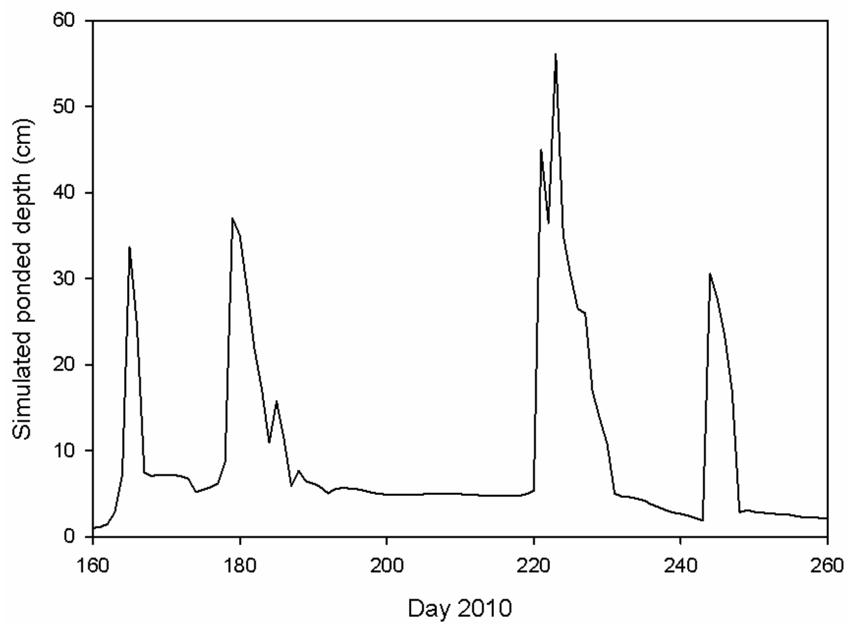

Figure 4. Simulated depth of ponding in the north depression for the 2010 growing season. The temporal trend compares well to the observed data but the simulated depths are smaller.

MIKE SHE is a deterministic, distributed and physically based model that allows for simulation of all major processes occurring in the land phase of the hydrologic cycle. The model allows for spatially varying precipitation, vegetation, soil hydraulic properties, and land uses. Water movement modeling in MIKE SHE includes overland and channel flow, unsaturated and saturated water flow, interception, and evapotranspiration. Since MIKE SHE is a distributed model, it has the potential to simulate areas with and without tile-drainage; subsurface drainage can be specified for each cell within the model area. Through previous Iowa Water Center funding to co-PI Helmers, we have used MIKE SHE to simulate subsurface drainage volumes, and the model has performed well in predicting measured volumes (Zhou et al. in review). The work described within will test MIKE SHE to determine if the model adequately captures the behavior of the potholes, specifically the extent and duration of ponding in the potholes. Preliminary modeling work suggests that MIKE SHE is capable of simulating the hydrologic behavior of these features (Figure 4) but needs to be studied and refined further.

15. **Related research:**

The occurrence of “prairie pothole” wetlands as a function of climate has been studied by some researchers (e.g. Zhang, et al., 2009; Kahara et al., 2009). However, most of the existing research has focused on potholes that were neither farmed nor drained with subsurface drainage tile. Farmed wetlands and drained potholes typify the nature of these features across much of Iowa. For example, Winter et al. (2001) characterized the hydrology of prairie potholes, noting that the majority of the water loss from these features is from evapotranspiration. For potholes with subsurface drainage (many of which have supplemental surface inlets at or near the bottom of the pothole), this is probably not the case. It is unclear, then, whether or not the findings of previous studies are applicable to farmed and drained potholes. For instance, Zhang et al. (2009) developed relationships for number of inundated potholes as a function of pothole water surface area for different precipitation events, with the goal of understanding frequency of pothole inundation as a function of "drought and deluge". While it is not clear how many of the features they studied (if any) were drained, because they used remote sensing imagery to identify potholes, they began with the assumption that ET was the primary route of water exit from the depression. Johnson et al. (2005) successfully demonstrated the ability of the WETSIM model to characterize wetland conditions in the prairie pothole region, but this model does not include an artificial drainage component. There is, therefore, a need to study and understand the precipitation response, hydrology, and modeling of these uniquely modified potholes.

Relatedly, most previous hydrology research on the 'downstream' impact of prairie potholes has focused on groundwater recharge (e.g. Winter and Rosenberry, 1998; Hayashi et al., 1998). Our study will fill a needed gap in studying the surface and near-surface hydrology of these features.

Furthermore, the most extensive studies of the prairie potholes have focused on assessing pothole size and geometry (e.g. Zhang et al. 2009). Our study will build upon this to connect geometric descriptions of these depressions to downstream hydrology.

16. **Training potential:**

The funding will support one MS student to assist in collecting the data, parameterize and run the MIKE SHE model for this site, and develop recommendations for further work. At the end of the project the graduate research assistant will be proficient in processing of topographic data, and running, calibrating, and validating the MIKE SHE model. As a graduate student in the ABE department at ISU, the student will also have the opportunity to teach part of a class or laboratory, present the results of the study at a professional conference, and prepare a refereed journal article. This training will prepare the student for a career as a hydrologist and modeler for industry or a state agency or to pursue a research career.

At least one undergraduate student will also participate in this project during the summer of 2012, funded by an NSF Research Experience for Undergraduates (REU) program in which Drs. Kaleita, Soupir, and Helmers participate (Kaleita is a co-PI).

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Zhang, B., F.W. Schwartz, and G. Liu. 2009. Systematics in the size structure of prairie pothole lakes through drought and deluge. *Water Resources Research*. 45(4): W04421.

Zhou, X., M.J. Helmers, Z. Qi. Field scale modeling of subsurface tile drainage using MIKE SHE. To be submitted to *Applied Engineering in Agriculture.*

Progress Report

Preliminary Findings: Estimation of NO3 concentration in water solutions by impedance spectroscopy should be more accurate than in soil samples. The root mean square error (RMSE) of the best model developed for solutions was half of that for the best model fitted to the soil data. However, for rigorous quantification, a different sensor design is necessary. Future work will therefore explore two other dielectric sensor designs from the one that we investigated in this USGS/IWC project.

Proposal submitted on the basis of these findings:
Project title: Low-cost radiofrequency sensor for real-time monitoring of nitrate concentration in water
Sponsor: USDA NIFA
Amt: $500,000

One undergraduate student (Env Sci major) was used on this project, through a research scholarship from the Iowa Space Grant Consortium. She will start graduate school (MS) in the fall to study water resources.

Watershed scale water cycle dynamics in intensively managed landscapes: bridging the knowledge gap to support climate mitigation policies

Basic Information

Title:	Watershed scale water cycle dynamics in intensively managed landscapes: bridging the knowledge gap to support climate mitigation policies
Project Number:	2012IA215G
Start Date:	9/1/2012
End Date:	8/31/2014
Funding Source:	104G
Congressional District:	IA-2nd
Research Category:	Climate and Hydrologic Processes
Focus Category:	Agriculture, Hydrology, Water Quantity
Descriptors:	None
Principal Investigators:	Thanos N Papanicolaou, Keith Edwin Schilling, Douglas Schnoebelen, Christopher Wilson

Publications

There are no publications.

Iowa Water Center
Annual Technical Report
FY 2011

Introduction

The Iowa Water Center is a multi-campus and multi-organizational center focusing on research, teaching and outreach activities. Its goal is to encourage and promote interdisciplinary, inter-institutional water research that can improve Iowa's water quality and provide adequate water supplies to meet both current and future needs of the state. The Iowa Water Center continues to build statewide linkages between universities and public and private sectors and to promote education, research, and information transfer on water resources and water quality issues in Iowa. The Center also plays a vital role in identifying critical water research needs and providing the funding or impetus needed to initiate research that cannot or is not being conducted through other means. Water quality remains a critical concern in Iowa.

Our ability to manage water during extreme climatic events has been tested in recent years with the flood events in Iowa of 2010. While not so recent, severe drought has also affected the economy and ecology of Iowa in negative ways. Managing Iowa’s water resources for flood or for drought is a difficult task. More challenging would be managing for the occurrence of flood and/or drought in rapid succession. Climatologists expect a warmer atmosphere in the coming decades, with more extreme fluctuations in our weather. The ability to manage and prepare for rapid variations in weather, especially precipitation, should be questioned. Do our land management systems perform well under both sides of the precipitation norm? How will water quality and quantity be affected under different cycles of extreme weather? Are the tools available to monitor and respond in adequate time to avoid adverse consequences to Iowa’s economy and human health? A variety of issues linking land management and water quantity and quality at multiple scales require further study. Identifying Best Management Practices for managing water quantity and for acceptable water quality during rapid cycle of climate extremes will be a primary focus this year and in the years to come. The Iowa Water Center plays a role in addressing these questions through administering the 104B program and garnering additional funds for other research projects.

Research Program Introduction

The Iowa Water Center has continued its work on water quality and water quantity, with particular emphasis on the role that changes in climate patterns have on water management. Iowa is somewhat unique in that it lies on a sharp precipitation gradient from east to west, making it a battle ground at times between water excess and water deficits. Our ability to manage water during extreme climatic events has been tested in recent years with the flood events in Iowa of 2010. While not so recent, severe drought has also affected the economy and ecology of Iowa in negative ways. Managing Iowa's water resources for flood or for drought is a difficult task. More challenging would be managing for the occurrence of flood and/or drought in rapid succession. Climatologists expect a warmer atmosphere in the coming decades, with more extreme fluctuations in our weather

The ability to manage and prepare for rapid variations in weather, especially precipitation, should be questioned. Do our land management systems perform well under both sides of the precipitation norm? How will water quality and quantity be affected under different cycles of extreme weather? Are the tools available to monitor and respond in adequate time to avoid adverse consequences to Iowa's economy and human health? A variety of issues linking land management and water quantity and quality at multiple scales require further study. Identifying Best Management Practices for managing water quantity and for acceptable water quality during rapid cycle of climate extremes has been a primary focus this year and will be a focus in the years to come. The Iowa Water Center plays a role in addressing these questions through administering the 104B program and garnering additional funds for other research projects.

Iowa has recently invested in LiDAR, giving the state elevation coverage with verticaln sensitivity of 20 cm. This unique asset allows the Iowa Water Center to support research addressing hydrology with detail that makes it unique compared to most other states. Research efforts will ultimately assist city planners and the general public in addressing storm water planning issue as well as improve our ability to understand surface water flow and its implication for both sediment and nutrient delivery to surface water.

Identifying the Primary Sources of Sediment in an Anthropogenically Altered Watershed

Basic Information

Title:	Identifying the Primary Sources of Sediment in an Anthropogenically Altered Watershed
Project Number:	2011IA240B
Start Date:	3/1/2010
End Date:	2/29/2012
Funding Source:	104B
Congressional District:	2
Research Category:	Not Applicable
Focus Category:	Sediments, None, None
Descriptors:	
Principal Investigators:	Thanos Nicholas Papanicolaou, Marian V.I. Muste, Douglas Schnoebelen, Larry Weber, Christopher Wilson

Publications

There are no publications.

IDENTIFYING THE PRIMARY SOURCES OF SEDIMENT IN AN ANTHROPOGENICALLY ALTERED WATERSHED

Annual Report – Year 2

Submitted to:
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May 2012

IOWA WATER CENTER at IOWA STATE UNIVERSITY

IIHR Hydroscience & Engineering

ABOUT IIHR- HYDROSCIENCE & ENGINEERING

IIHR – Hydroscience & Engineering is a unit of the College of Engineering at the University of Iowa. It is one of the nation's oldest and premier environmental fluids research and engineering laboratories. IIHR seeks to educate students on conducting research in the broad fields of river hydraulics, sediment transport, and watershed processes. IIHR has 44 faculty members and research engineers at the Ph.D. level, 8 postdoctoral scholars, and about 113 M.S. and Ph.D. graduate students. IIHR's 30 staff members include administrative assistants (including grant accounting and reporting support), IT support, and machine/ electrical shop engineers.

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7. AUTHOR(S) A.N. Thanos Papanicolaou and Christopher G. Wilson		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS IIHR- Hydroscience & Engineering The University of Iowa 300 South Riverside Drive Iowa City, IA 52242-1585		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO.
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15. SUPPLEMENTARY NOTES		

16. ABSTRACT

The spatial and temporal scales of erosion processes in the upland areas and stream channels of Midwestern agricultural watersheds have been dramatically altered by anthropogenic activities including tillage and channel straightening. The combined effects of tillage-induced erosion and channel degradation have resulted in sediment becoming a major water quality problem in states like Iowa. To assist policy makers and watershed planners in identifying areas that are prone to erosion and determining the location, type, and number of Best Management Practices needed to control sediment-related problems, we have used an established tracing technique with naturally occurring radionuclides (Berylium-7 and excess Lead-210) for quantifying and partitioning the primary sources (i.e., uplands, banks, and bed) of suspended sediment to stream loads under different magnitude, hydrologic events in a representative, agricultural, headwater system. During the second year of this two-year project, further analysis of the data collected in the first year was conducted and culminated into a recently published manuscript (Wilson et al., 2012). The additional analysis focused on the observed non-linearity or hysteresis between suspended sediment concentration and flow discharge during the sampled runoff events. This hysteresis was useful for interpreting the results from the radionuclide partitioning of the sediment sources to stream suspended load. Finally, the data collected during the first year of the study were made available for the verification of watershed erosion models. The initial set of simulations using WEPP-3ST1D proved promising, yet further study of the results is needed to explain the differences between measured and modeled sediment loads during the large third event, a flash flood.

17. KEY WORDS Key words: Sediment sources, ^{7}Be, $^{210}Pb_{xs}$, Upland erosion, Bank erosion	18. DISTRIBUTION STATEMENT No restrictions.

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IDENTIFYING THE PRIMARY SOURCES OF SEDIMENT IN AN ANTHROPOGENICALLY ALTERED WATERSHED

Annual report – Year 2

May 2012

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Annual Project Report Submitted to the Iowa Water Center
and the U.S. Geological Survey

U.S. Geological Survey Grant No. 2010IA149B

For the period March 1, 2011 to February 29, 2012

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2. Focus Categories: Sediments

3. Research Category: SED

4. Keywords: Sediment sources, ^{7}Be, $^{210}Pb_{xs}$, Upland erosion, Bank erosion

5. Duration of Project: March 1, 2010 – February 29, 2012

6. Congressional District: 2nd

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1. INTRODUCTION

1.1 Problem Statement

The spatial and temporal scales of erosion processes in the upland areas and stream channels of Midwestern agricultural watersheds have been dramatically altered by anthropogenic activities including tillage and channel straightening. These changes have, thereby, complicated our understanding of sediment dynamics and predictions of sediment loads in these watersheds. Further, the combined effects of tillage-induced erosion and channel degradation have resulted in sediment being a major water quality problem in states like Iowa (Helmers et al., 2007). In response, governmental agencies have attempted to curb this sediment problem through the development and implementation of Best Management Practices, or BMPs.

To some degree, these BMP programs have been successful; however, in some instances, the downstream water quality has actually worsened even more than 10 years after the programs were installed (e.g., Garrison and Asplund, 1993; Schilling et al., 2007). This has led to questions, such as *"Were the BMPs installed in the wrong place or does it just take several years to see the downstream benefits of the BMPs?"*

To assist policy makers and watershed planners in attacking the sediment problem at the source, we have used an established tracing technique with naturally occurring radionuclides (Berylium-7, ^{7}Be, and excess Lead-210, $^{210}Pb_{xs}$) for identifying the primary sources (i.e., uplands, banks, and bed) of suspended sediment to stream loads under different magnitude hydrologic events in a representative, agricultural, headwater system.

> *The combined effects of tillage-induced erosion in uplands and channel degradation in streams have made sediment a major water quality problem in states, like Iowa (Helmers et al., 2007).*

By quantifying the dominant sediment source(s) in these streams, we can identify and target those areas that need BMPs to control sediment and attached nutrients, such as phosphorus. Moreover, we can improve our water quality models, which are used to develop sound management strategies. The inability to identify key sediment sources in a watershed plagues Iowans as we struggle to keep our local fields productive and waterways healthy, while defending accusations from downstream communities.

1.2 Background

A widely used method of quantifying suspended sediment loads from a watershed is through direct monitoring of individual runoff events and developing a sediment budget. This is especially true in headwater systems, which are relatively small so there is no need for numerous sampling locations.

Tracing techniques have been utilized to supplement the direct monitoring of individual runoff events by characterizing the sources and pathways of soil and sediment within a fluvial system. Soil and sediment tracers (Foster, 2000) have been based on sediment properties including radionuclide characteristics (e.g., Walling and Woodward, 1992; Busacca et al., 1993; Smith and Elder, 1999; Vanden Bygaart and Protz, 2001) and stable isotopic chemistry (e.g., Allegre et al., 1996; Filippi et al., 1998; Kendall and Doctor, 2004; Fox and Papanicolaou, 2007). However, new technologies are still needed to specifically link tracer signatures to the parameters controlling erosion mechanisms across a watershed.

Naturally occurring fallout radionuclides are effective tracers and can help differentiate sediment sources, if appropriate tracers are used, with half-lives that are relative to the time scales of the driving forces. Single runoff events, which occur on timescales of hours and days, are best studied with radionuclides that decay on similar scales (e.g., Whiting et al., 2005; Wilson et al., 2008), as is the case with ^{7}Be (half-life, $t_{1/2}$ = 53.3 days), supplemented with $^{210}Pb_{xs}$ ($t_{1/2}$ = 22.3 years).

^{7}Be is produced continuously in the atmosphere through spallation (or breaking up) of nitrogen and oxygen atoms by cosmic rays. ^{210}Pb is produced as an intermediate daughter in the Uranium-238, ^{238}U, decay series. The ^{238}U ($t_{1/2}$ = 4.5 x 10^9 years) in soils decays through a series of daughters to gaseous Radon-222, ^{222}Rn, ($t_{1/2}$ = 3.83 days). A portion of the ^{222}Rn remains in situ, while some of it diffuses into the atmosphere. The ^{222}Rn in both the soil and the atmosphere further decays to ^{210}Pb through a series of short half-lived daughters. The ^{210}Pb produced within the soil is termed "supported", while the atmospheric ^{210}Pb is termed "excess" ($^{210}Pb_{xs}$) and is used in this study.

In the atmosphere, the ^{7}Be and $^{210}Pb_{xs}$ attach to aerosol particles and are delivered to the landscape mainly during precipitation events. The radionuclides quickly and strongly bond to fine surface soils (namely, silt and clay; He and Walling, 1996) through cation exchange. Activities of ^{7}Be and $^{210}Pb_{xs}$ decrease exponentially moving downcore in the soil column (e.g., Wallbrink and Murray, 1996; Bonniwell et al., 1999; Wilson et al., 2003) for only a few centimeters.

The fine, high activity, soils at the ground surface are preferentially mobilized by raindrop impact and eroded by runoff (Rhoton et al., 1979). The preferential removal of fine soil particles during storm runoff events leads to enrichment (Rhoton et al., 1979) of the radionuclide activity in the eroded sediment by concentrating the particles with high radionuclide activities.

The eroded surface soils and adsorbed radionuclides are transported downstream where they are mixed with sediment from collapsed stream banks and entrained streambed material (Figure 1). In contrast to the high activities of the eroded surface soils, the channel sediments tend to have lower activities. Stream banks receive little atmospheric input of the radionuclides due to near-vertical slopes (Whiting et al., 2005), and stream bank failure can remove large volumes of material (Thorne, 1992) that dilute the high-activity bank soil at the surface with a much larger volume of low-activity sediment from deeper in the collapsed bank. In addition, the sediment from the streambed has resided there for extended periods undergoing substantial decay without radionuclide replenishment.

The resulting signature of the suspended sediment will reflect the mixture of the surface soils and channel sediments. High radionuclide activities in the suspended sediment suggest a large proportion of

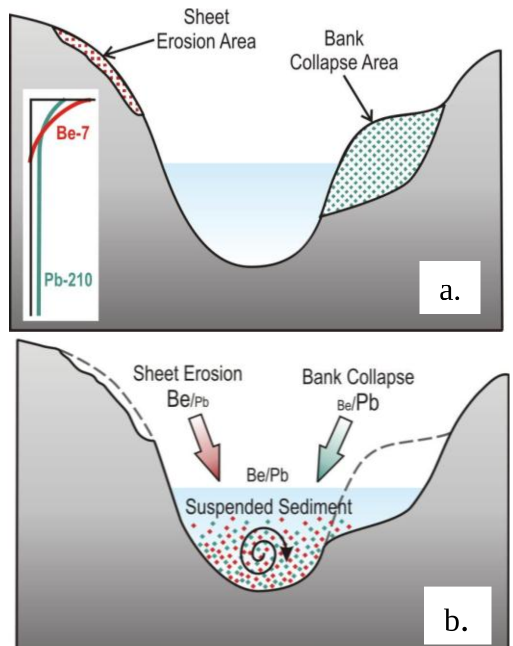


Figure 1. Depth distribution of ^{7}Be and $^{210}Pb_{xs}$ in source areas. (a) Depth distribution of ^{7}Be and ^{210}Pb prior to the event. (b) Sediments from the eroded source areas are mixed in the channel as they are carried downstream.

recently eroded surface soil. Conversely, lower activities suggest dilution by channel sediments. A simple, two end-member mixing model can determine the relative contribution of each source area (i.e., soil surface and channel) to the fine suspended sediment load. The radionuclide signatures of suspended sediment lie roughly along the mixing line between the signatures of the two end-member sources of sediment.

This method was coupled with direct flux measurements and developed sediment rating curves to parse out the different contributions to the fine suspended sediment loads of an agricultural stream. Multiple techniques used in conjunction with one another tend to produce clearer distinctions.

2. OBJECTIVES AND TASKS

The goal of this study was to quantify and, ultimately, partition fine suspended sediment loads in an intensively agricultural, headwater system that is representative of the U.S. Midwest during individual runoff events to understand the relationship between different sediment delivery processes. The long term vision of the study is to assist policy makers and watershed planners in identifying the areas that are prone to erosion (i.e., hotspots) and determining the location, type, and number of countermeasures, or BMPs, and in-stream stabilization structures, needed to control sediment-related problems.

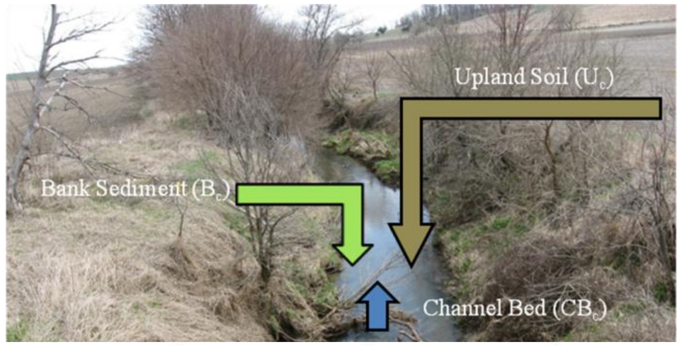
To assist policy makers and watershed planners in attacking the problem at the source, we used an established, powerful tracing techniques, namely naturally occurring radionuclides (^{7}Be and ^{210}Pb$_{xs}$) for isolating the primary sediment sources (i.e., uplands, banks, and bed) under different magnitude hydrologic events.

3. METHODOLOGY

The nature of this study involved field, laboratory, and numerical undertakings to partition the sediment contributions of uplands, U_c, channel banks, B_c, and channel bed sediment, CB_c, to the suspended sediment load, Q_s, in the anthropogenically altered Clear Creek, IA Watershed (CCW; Figure 2). In order to address this goal, we identified three tasks. Tasks 1 and 2 were conducted during the first year of this study, much of which was discussed in the first annual report. Further analysis of the results from these tasks was completed in year 2 that culminated in a recently accepted, peer-reviewed, journal article (Wilson et al., 2012). In this annual report for year 2, Tasks 1 and 2 are summarized with only the additional analysis presented herein. Task 3 was focused in year 2 of this project with the results also presented herein.

Task 1: Develop sediment rating curves for CCW for different magnitude hydrologic events. One of the best means of quantifying suspended sediment loads from a headwater watershed is through direct monitoring of individual runoff events. However, this monitoring can become costly, laborious and, if it is conducted only at the system outlet, provides merely a net load estimate.

In this study, we developed sediment rating curves to determine a sediment budget for representative hydrologic events in CCW (Papanicolaou and Abaci, 2008). For constructing the sediment rating curves, we used in-stream pressure transducers to quantify the flux of water (Q_w). Sediment concentrations were determined from grab samples and in-stream samplers, as well as a Sedimeter, which measured turbidity continuously. These measurements were coupled with the flow data to determine Q_s. The sediment flux data from the uplands and the channel were integrated over different runoff events to provide a sediment budget (Figure 2).



$$Q_s = \int U_C + \int B_C + \int CB_C$$

Figure 2. A sediment budget for a stream. Sediment sources are the uplands, channel banks, and bed.

Task 2: Quantify the relative partitioning of sediment sources that contribute to the suspended sediment load of CCW using radionuclide tracers. We quantified the relative proportions of eroded upland soils and channel derived sediments in the suspended load of sampled events using ^{7}Be and ^{210}Pb$_{xs}$ (e.g., Wilson et al., 2012). Initially, unique radionuclide signatures of the potential source sediments in the watershed (specifically uplands, channel banks, and the channel bed) were identified to quantify their contributions to the suspended load. The radionuclide activities of these sediment sources were compared to the activities of suspended sediment samples collected over different parts of sampled runoff events to determine their relative contributions using a two end-member mixing model.

Task 3: Incorporation of the unmixing model results into the Clear Creek Digital Watershed for model verification. The data from this study were made available to the Clear Creek Digital Watershed for refinement and verification of different watershed models. The data were initially used in the coupled Watershed Erosion Prediction Project- Steep Stream Sediment Transport 1-D model (WEPP – 3ST1d; Papanicolaou and Abaci, 2008; Dermisis et al., 2011) to simulate the sampled events.

4. STUDY SITE

The 260-km^2 Clear Creek Watershed is a Hydrologic Unit Code (HUC) - 10 watershed in southeastern Iowa (Figure 3) that is representative of most watersheds in the Midwest especially regarding land use (predominantly agricultural), soil type/order (Alfisols and Mollisols), and climate (humid-continental). In addition, CCW is well instrumented by IIHR Hydroscience & Engineering at the University of Iowa to monitor rainfall, streamflow, soil moisture, and infiltration/runoff, as well as other water quality parameters making it an ideal natural laboratory.

Figure 3. Clear Creek, IA watershed. (a) CCW with the South Amana sub-watershed circled in red. (b) A picture of the outlet of the system. (c) A picture of a sampled test field. Samples were collected at the shoulder, backslope, and toe of this hillslope. From Wilson et al. (2012).

Anthropogenic activities, including intensive agriculture, urbanization, and stream channelization, have strongly influenced flow and sediment processes within the watershed. The intensive agriculture, in conjunction with highly erodible soils and steep slopes, has produced some of the highest rates of erosion and non-point source pollution in Iowa and the United States (see the USDA-NRCS 2007 National Resources Inventory). Stream destabilization from widespread channelization and drainage system construction has further increased sediment loadings to the stream (Rayburn and Schulte, 2009). The high sediment loads have exacerbated damage resulting from recent flooding, thus prompting local concern.

This study was focused in a 26-km^2 headwater catchment of CCW, namely the South Amana sub-watershed (Figure 3). This sub-watershed is dominated by agriculture, with 85% of the land supporting corn/soybean fields and the remaining 15% under grassed pastures. Hillslopes have an average gradient of 4% (range = 1% to 10%) and contain silty clay loams of the Tama-Downs soil series in the uplands and Colo-Ely soil series along the floodplains.

The stream network consists of two 1st-order streams that are approximately 6 river km long with slopes of 0.16%. The streambed is dominated by sand-sized particles having a median grain size of 0.31 mm (Ellis, 2009). The channel banks range from gradually sloping (height ~0.5 m) to nearly vertical (height ~ 3 m) at the outlet.

The outlet of the sub-watershed was conventionally defined as a 76-m, straight reach below the confluence of the two 1st-order streams (Figure 3). The average water discharge and sediment loadings through this reach are 5.9 x 10^6 m^3/yr and 5.0 x 10^3 tons/yr, respectively (Abaci and Papanicolaou, 2009).

The general climate of CCW is typical of other mid-continental locations; hot summers, cold winters, and wet springs are the prevailing trends (Ruhe, 1956). An average growing season in southeast Iowa lasts approximately 180 days. Average annual precipitation is 889 ± 220 mm/yr with convective thunderstorms prominent in the summer and snowfall in the winter.

5. RESULTS AND DISCUSSION

5.1 Tasks 1 and 2

Continued analysis of the sediment rating curves was conducted in year 2 of this project for incorporation into a journal manuscript (Wilson et al., 2012). As a review, the suspended sediment fluxes (Q_S) from the sampled events were quantified over a 24-hour period from the initiation of the rainfall using the following methods: (1) multiplying the measured suspended sediment concentration (C_S) and the flow discharge (Q_W); (2) applying individual discharge-sediment flux relationships for each event (herein called individual event relationships; Figure 4); and (3) applying a cumulative discharge-sediment flux rating curve for the site incorporating measurements collected over 5 years (originally in Zager, 2009).

The suspended sediment loads (Table 1) that were calculated using the C_S-Q_W measurements and the individual event relationships were similar (<10% difference) for each event; however, the cumulative rating curve for the outlet under-predicted the suspended loads of smaller events (between 21% and 64%, when compared to the measurement-based load) and over-predicted the loads for larger events by about 27%.

Table 1. Runoff (m^3) and suspended sediment loads (kg) for individual events.

Event Number	Runoff	$C_S * Q_W$	Individual Event Relationships	Cumulative Rating Curve
1	47, 390	48, 646	51, 917	32, 945
2	83, 031	222, 062	241, 523	83, 360
3	977, 623	3, 640, 256	3, 531, 750	4, 494, 017

One of the primary reasons for the differences between the sediment rating curve loads and the measurement-based loads was the non-linearity between C_S and Q_W during the runoff events. The sediment rating curve assumed as a linear relationship between sediment concentration and flow discharge, while the measured values and individual event relationships accounted for the nonlinearity, or hysteresis (Figure 5). During the sampled events, a clockwise hysteresis was observed. Clockwise hysteresis is often explained as resulting from source material exhaustion (e.g., Williams, 1989; Moog and Whiting, 1998; Baca, 2008; Salant et al., 2008; Smith and Dragovich, 2009) from the limited availability of loose fine material in the uplands.

Using the measurement-based sediment loads that accounted for the hysteresis along with the load partitioning analysis based on the radionuclide activities for three successive events showed that 67 ± 20% of the material was upland-derived during the first event. For the second event, 34 ± 11% of the suspended sediment was derived from the uplands. During the third event, however, the sediment load was dominated by channel sediments (79 ± 29%).

The radionuclide analysis showed a decreasing proportion of eroded upland soils in the three successive events, which was supported by the clockwise hysteresis from source material exhaustion. It should be noted that the slopes of the hysteresis trends decrease through the sequence of events. In Event 1, the slope is nearly vertical (Figure 5a), while for Event 2, the slope decreases to approximately 2 to 1 (Figure 5b), and the slope is nearly horizontal in Event 3 (Figure 5c). The slope decreases as the ratio between the concentration values and discharges decreases, which means less sediment is mobilized for the consecutively higher flows. This can be attributed to less material being readily available for erosion in the subsequent events since it was carried away by earlier events.

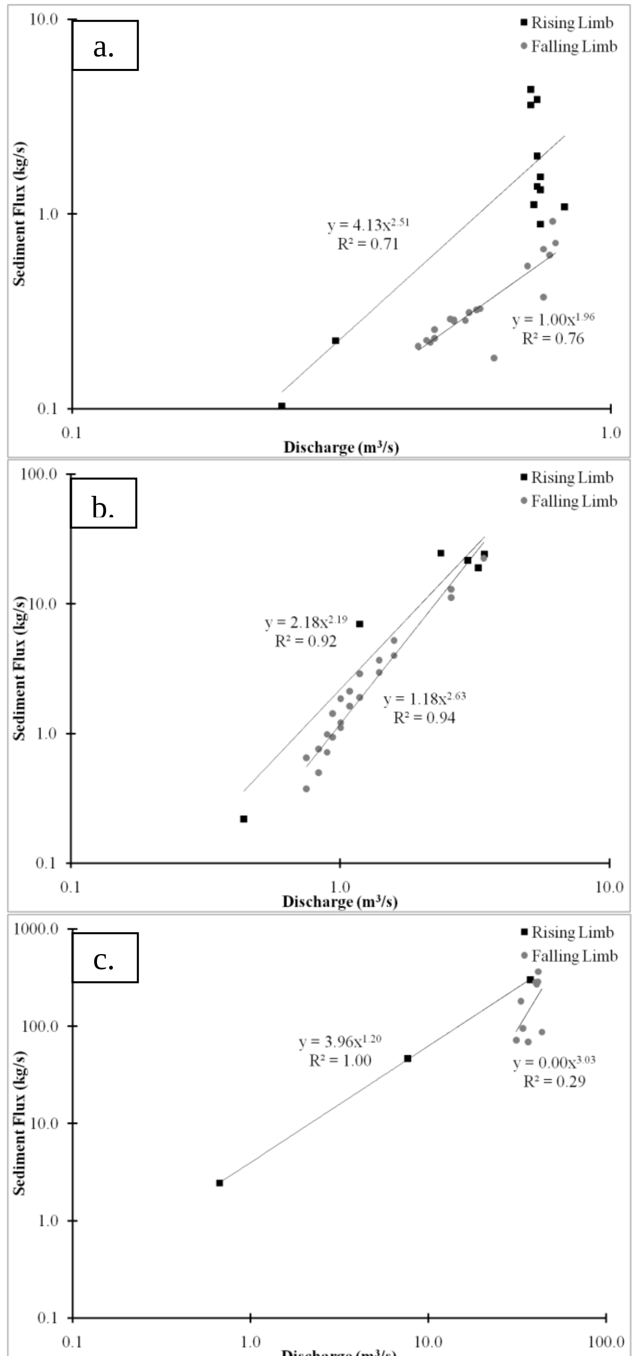


Figure 4. Individual event relationships. Relationships between sediment flux and flow discharge for three sampled events. Samples are separated into those collected during the rising and falling limbs of each hydrograph. (a) Event 1; (b) Event 2; (c) Event 3. From Wilson et al. (2012)

5.2 Task 3

For Task 3 of this project, the data collected during the first and second tasks were made available and applied to watershed models for verification purposes. Simulations using the coupled WEPP-3ST1D model for the South Amana sub-watershed were conducted using the new information gleaned from this study. The model had previously been calibrated in Abaci and Papanicolaou (2009) and Dermisis et al. (2011).

Briefly, WEPP is a spatially distributed, process-based, hydrologic/ erosion model that includes detailed sets of management practices. Key sub-routines in the model also include climate generation, snow accumulation and melt, irrigation, topography (i.e., downslope curvature), infiltration, overland flow hydraulics, water balance, plant growth, residue decomposition, soil disturbance by tillage, and erosion/deposition. WEPP has been previously used to simulate erosion within the upland areas of CCW (Abaci and Papanicolaou, 2009).

3ST1D is a one-dimensional numerical model developed by Papanicolaou et al. (2004) for simulating unsteady flow and sediment transport in steep streams. The input files of 3ST1D, including the boundary and initial conditions, grain size distribution and cross-sectional data, were modified to read basic output data from the WEPP hillslope simulations, such as runoff, storm duration and soil loss (Dermisis et al., 2011). This model routes the sediment from the hillslopes (determined by WEPP) through the stream channels.

The sampled events were simulated in succession by modifying relevant input parameters for the successive events with outputs from the previous events. The relevant parameters included 5-minute breakpoint precipitation, critical shear stress, effective hydraulic conductivity, initial saturation, cumulative rainfall since last tillage, initial canopy cover, and days since last tillage/ harvest. Figure 6 shows the comparison between the measured values of runoff volume and suspended sediment load collected during the sampled events for the South Amana sub-watershed. For runoff volumes, the model simulations compared well with the measured values, having percent differences less than 16%. However, the percent differences between the measured and predicted suspended sediment loads were between 10 and 74%. The only value that did not simulate well was the suspended sediment load for the third event, which was an extreme flash flood. The model under-predicted the load value. On–going analysis is being conducted with these simulations; however, the data from this study are proving useful. Other simulation using AGNPS are currently being developed, with future simulations of SWAT on the horizon.

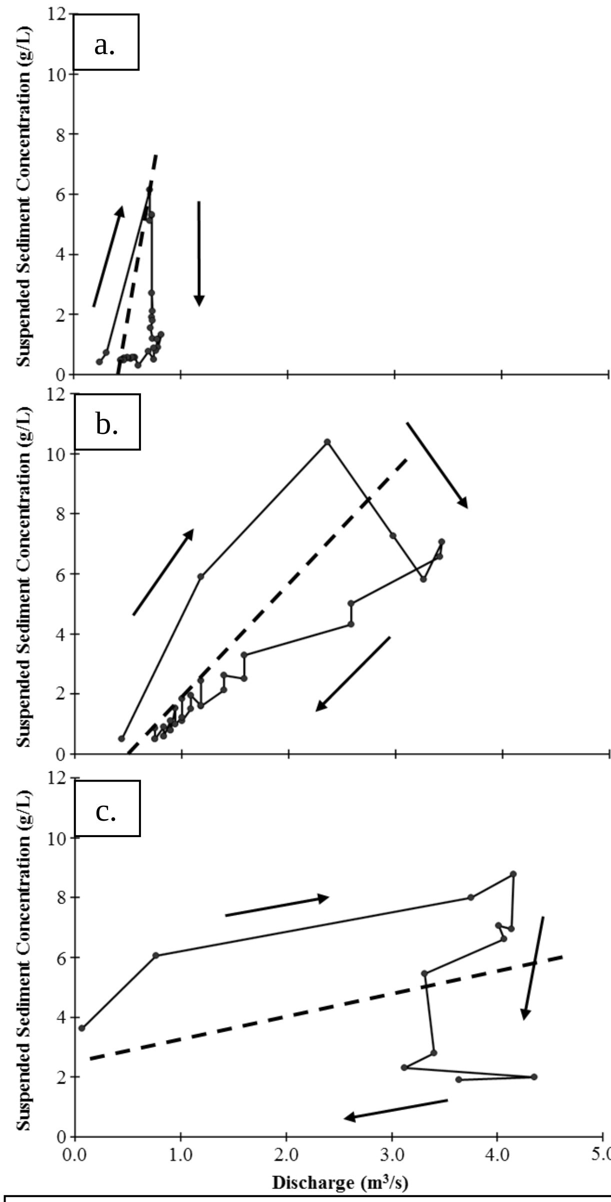


Figure 5. Suspended sediment concentration and discharge relationships. Graphs showing the relationship between suspended sediment concentration and discharge, as well as the associated hysteresis, for each event. The dark, dashed lines show the general slopes of the hysteresis trends. (a) Event 1; (b) Event 2; (c) Event 3. From Wilson et al. (2012).

6. CONCLUSIONS

During the second year of this two-year project, a further analysis of the data collected in the previous year was conducted. This analysis culminated into a recently published, peer-reviewed manuscript (Wilson et al., 2012).

The additional analysis focused on the observed non-linearity or hysteresis between C_S and Q_W during the sampled runoff events. During three successive events, a clockwise hysteresis was observed. Clockwise hysteresis can be explained as the result of source material exhaustion from the limited availability of loose fine material in the uplands. This hysteresis was useful in further interpreting the results from the radionuclide partitioning of the sediment sources to stream suspended load.

The clockwise hysteresis from source material exhaustion and the decreasing slopes observed in the hysteresis plots (Figure 5) suggest that less material was readily available for mobilization during subsequent events. The radionuclide analysis showed a similar decreasing proportion of eroded upland soils in the three successive events. Hence, the majority of loose, fine sediment in the uplands was flushed during the first event.

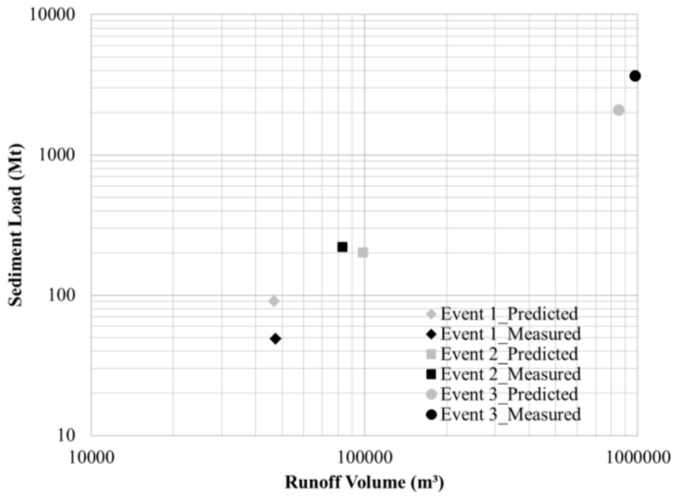


Figure 6. Comparison of measured vs. simulated runoff and sediment loads. A graph comparing the measured runoff volume and sediment loads from three sampled events with values predicted from WEPP-3ST1D model simulations.

Finally, the data collected during the first year of the study were used for the verification of watershed erosion model simulations. The initial set of simulations using WEPP-3ST1D proved promising, yet further study of the results is needed to explain the differences in the sediment load during the large third event.

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Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS.

Basic Information

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End Date:	5/1/2012
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Congressional District:	1
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Descriptors:	
Principal Investigators:	Ramanathan Sugumaran, John DeGroote

Publications

There are no publications.

Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS

Basic Information

Title: Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS.

Principal Investigators: Ramanathan Sugumaran, John DeGroote, Bernard Conrad

External Collaborators: Paul Meyermann, John Voorhees, Rebecca Kautern

Start Date: September 2011

End Date: May 2012

Publications

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3. Conrad, B., Ramanathan, S., DeGroote, John. 2012. Urban Storm Water Planning Utilizing LiDAR, the WinSLAMM Model, and GIS. 2012 Iowa Water Conference. Ames, Iowa

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Community-wide Urban Storm water Planning Utilizing LiDAR, the WinSLAMM

Problem and Research Objectives

Urban watersheds are composed of a complicated spatial fabric and are influenced by a wide range of economic, policy, and public interest drivers and constraints. With increased regulation of storm water discharges taking place on a national basis, there are greater pressures on municipalities to develop effective urban storm water management strategies. Thus, there is a great need for effective tools which can aid the design and execution of such strategies by identifying hot-spot areas contributing to excessive discharges and pollutants and to evaluate potential best management practices (Wong 2010). Although concern over urban storm water runoff quantity and quality has grown, there has been a lack of accurate spatially explicit models for better storm-water planning.

Urbanization of watersheds has been known to create problems in regards to water quality (Roesner 2001; Walsh 2000). Urban areas consist of manmade impervious structures that reduce infiltration made possible by permeable surfaces with streets considered to be the major contributor of pollutant runoff (Sartor, 1974). Urban runoff comes from a variety of different sources such as streets, sidewalks, and roofs (Bochis, 2005) which is conveyed by advanced water management systems quickly to natural waterways. However, water quality is important for human uses and ecological reasons to ensure that water sources do not become tainted from various pollutants such as sediment and phosphorus. Better Management Practices (BMPs) can reduce the amount of pollutants being discharged as well as slow down water movement by creating more effective infiltration areas (D'Arcy 2000). To effectively implement BMPs requires topographic knowledge of an area to determine optimal locations of such devices, such as biofiltration devices and detention ponds.

Determining urban drainage areas and patterns is a complex process that is drastically enhanced by incorporating a Geographic Information System (GIS) (Sui, 1999). GIS has capabilities to model hydrology to determine hazards or vulnerability by layering parameters including slope, soil characteristics, precipitation, and others (Clark 1998). Together with a Digital Elevation Model (DEM), GIS can be used to process and determine hydrological features of the ground's surface (Garbrecht 1999). DEMs are available at different spatial resolutions and it is understood that a higher spatial resolution will result in more accurate results. Higher spatial resolution DEMs are increasingly being developed through LiDAR (Light Detection and Ranging) technology. Iowa is one of the first states in the United States to collect LiDAR data statewide.

To model urban hydrology a DEM is needed to provide an accurate topographic representation of the study area. Using a DEM with high spatial resolution is important to accurately display appropriate drainage areas (Liu 2005). LiDAR has become much more commonly used to create high spatial resolution DEMs available for analysis (Hodgson, 2003). Higher spatial resolution can be prone to errors, although if it is preprocessed carefully to remove errors, LiDAR data can lead to improved results (Barber 2005). Figure 1 shows a comparison between 1, 5, 10, and 30 meter DEMs created using LiDAR data.

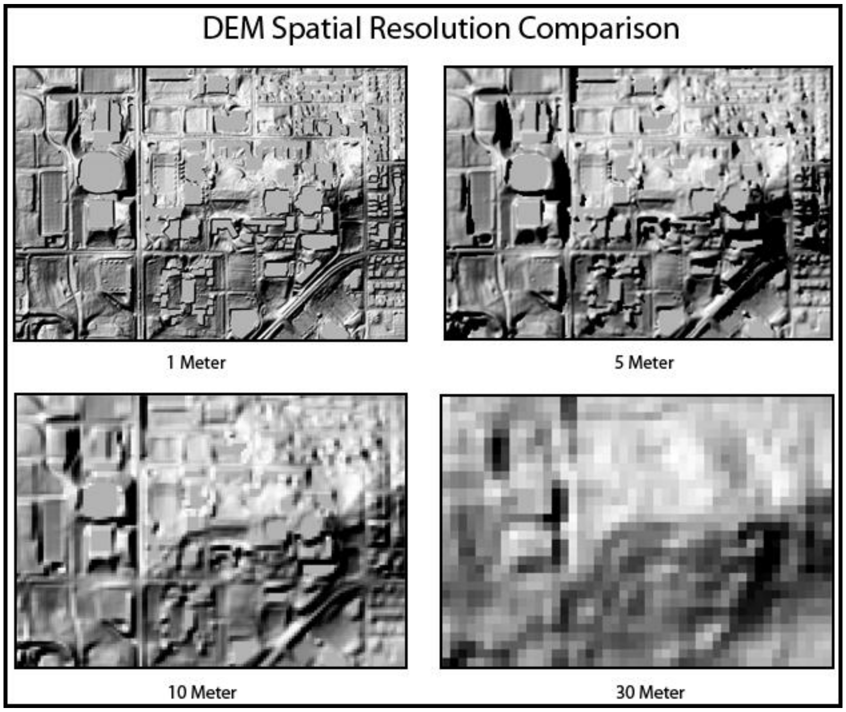

Figure 1: Comparison of DEM Spatial Resolution derived from LiDAR

Urban watersheds are complex structures that require sophisticated modeling to estimate runoff and pollutant loads. There are many urban storm water models available include MUSIC (Model for Urban Stormater Improvement Conceptualization) and P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles, and Ponds) (Elliot, Trowsdale 2007). The Source Loading and Management Model (SLAMM) has been in existence since the late 1970s with constant updates and improvements with the purpose of modeling common small rainfalls (Pitt 2002). Many other urban storm water models are used to model heavy, less frequent rainfall. SLAMM was created to address some of the weaknesses of other models. Models such as MUSIC create drainage systems as well using links and nodes (Elliott, Trowsdale 2007). SLAMM estimates runoff and pollutant loads from areas with unique soil/land use combinations and lumps them by catchment area without drainage models because assumptions with the design of drainage systems are not appropriate for water quality models (Pitt 2002). SLAMM has been expanded to include a wide variety of source area and outfall control practices including: Infiltration practices, wet detention ponds, porous pavement, street cleaning, catchbasin cleaning, and grass swales (Pitt 2002).

The first objective of the project is to *investigate the effect of spatial resolution for urban storm water modeling.* The second objective is *to derive precise topographic representation from LiDAR elevation data and high resolution remote sensing data and to incorporate those data into WinSLAMM to predict sediment and phosphorous runoff from an urban watershed*. The study area is the University of Northern Iowa's Campus located in

Cedar Falls, Iowa (Fig 1). The University of Northern Iowa resides within the Dry Run Creek Watershed. The size of campus is 912 acres consisting of buildings, impervious surfaces, pervious landscapes, and waterways.

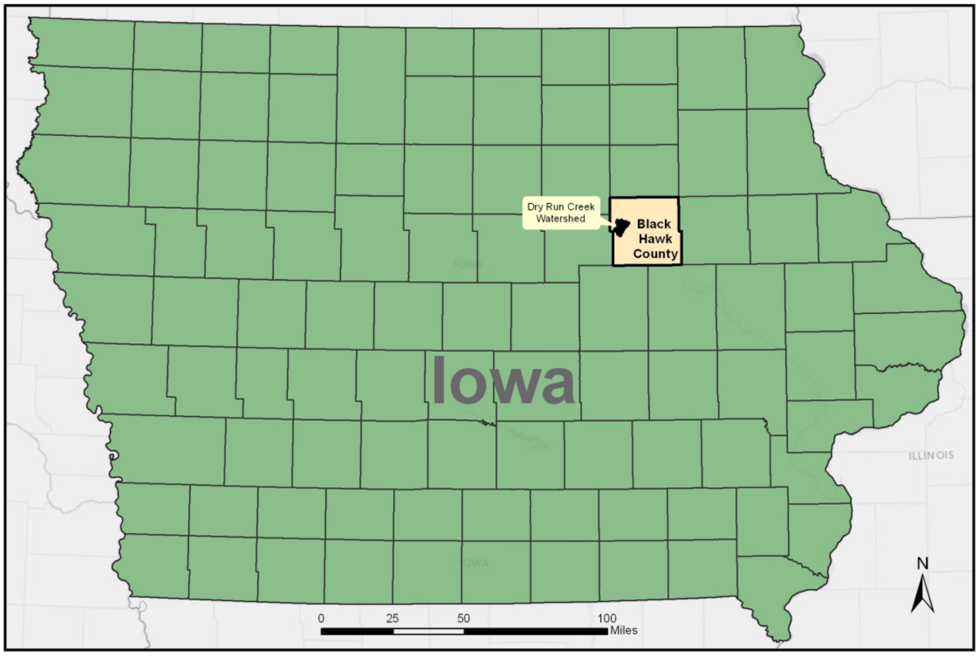

Figure 2: Study Area

Methodology

Figure 3 demonstrates the overall process and which were used to effectively utilize LiDAR data for WinSLAMM modeling of runoff and pollutant loads. The LiDAR data was processed using ESRI's ArcGIS for Desktop Advanced. The process consisted of converting the 46 ASCII bare earth tiles into multipoint feature classes that could then be added to a terrain network and converted to a raster which is the final DEM. The DEM was then edited to fix the topography of areas that created "digital dams." These digital dams are locations where water could flows through in the real world, such as underpasses or culverts, but which LiDAR was not able to accurately capture. A detailed and accurate stream network was used and slightly altered to match and was then "burned" into the DEM to force water to flow as it would naturally.

The remainder of the analysis consisted of utilizing the tools found available within ArcHydro, a hydrological modeling extension for ArcGIS. Tools used included Flow Direction which derives the direction of where the water would flow from any given cell. This is an important tool that is used to remove areas where water would puddle in. Once the DEM is completed, the Flow Accumulator can be used to set criteria that can be used to select pixels that other pixels flow into. These pixels are then extracted which make up streams and are used to extract sub-basins, which are used in WinSLAMM.

The delineated sub-basins were then used to split a feature class that contains detailed representation of land use/cover collected through field work (Table 1). This information is imperative for WinSLAMM to operate. The features were split to show all the land use/cover features that exist within each sub-basin. The areas of each sub-basin's features were then aggregated together for easier user input. The features were then manually entered into WinSLAMM and the total sediment and phosphorus loadings were recorded for each sub-basin.

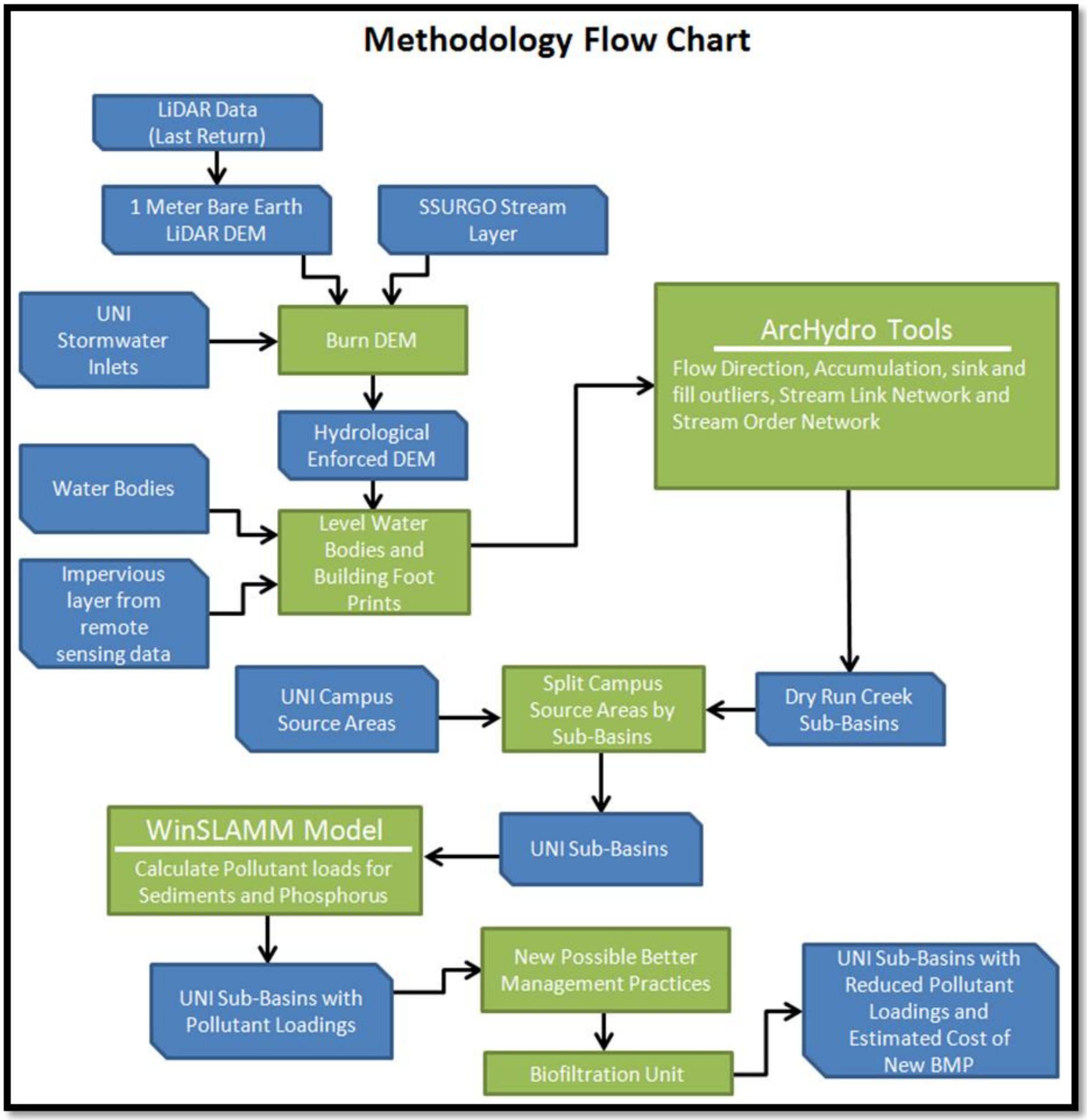

Figure 3: Methodology Flow Chart

Table 1: Feature descriptions gathered through field work

Feature	Drainage	Paved/Unpaved	RoofType	Landuse
Driveway	Connected/ Disconnected	Paved/Unpaved	NA	Institutional/ Industrial
Landscape	NA	NA	NA	Institutional/ Industrial
Other Impervious	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Other Pervious	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Parking	Connected/ Disconnected	Paved/Unpaved	NA	Institutional/ Industrial
Road	Connected/ Disconnected	NA	NA	Institutional/ Industrial
Roof	Connected/ Disconnected	NA	Pitched/ Flat	Institutional/ Industrial
Sidewalk	NA	NA	NA	Institutional/ Industrial
Water	NA	NA	NA	Institutional/ Industrial

Objective 1: Determine the best spatial resolution for urban storm water management. After the DEM was created through LiDAR processing, it was then resampled from 1 meter into 5, 10, and 30 meter resolution DEMs. The process of delineating sub-basins was then redone for each new DEM and the results were presented based on the total number of sub-basins as well as the average size. *Objective 2: derive accurate spatial data from LiDAR elevation data and high resolution remote sensing and to incorporate data into WinSLAMM*. After the sub-basins were created, they were used to extract UNI campus source areas from a shapefile which was built by gathering data through field work. Once all the features were extracted based on the sub-basin, a printout was created through a Python script that accumulated the total area of unique land features within

the sub-basin . These values were used to parameterize WinSLAMM which was used to calculate runoff and pollutant loadings by each sub-basin.

Principal Findings and Significance

The first objective was to evaluate the most efficient spatial resolution to determine sub-basins. Four DEMs were created based on 1, 5, 10, and 30 m resolution DEMs (Figure 3). For each sub-basin the threshold used to delineate was 500 cells. This user defined threshold defines downstream cells which accumulate flow from at least the threshold (in this case 500) number of cells. By doing this a series of streams is created based on the DEM. There is a wide range of variability with selecting a threshold (Jenson 1991; Wang 1998; Da Ros 1997). A smaller threshold will result in a very detailed stream network while a large threshold will produce a stream network consisting of the main large, pronounced streams. The 1 Meter DEM was selected and used through the rest of the project with 78 sub-basins within the study area (Table 2). This is because the 1 m DEM allows the derivation of detailed sub-catchment boundaries which allow for more precise WinSLAMM modeling.

Table 2: DEM Comparative Output

Digital Elevation Model	1 Meter	5 Meter	10 Meter	30 Meter
Cell Threshold	500			
Sub-Basins	741	268	67	11
Average Area of Cell Size (Acre)	20.27	56.2	225.02	1371.98

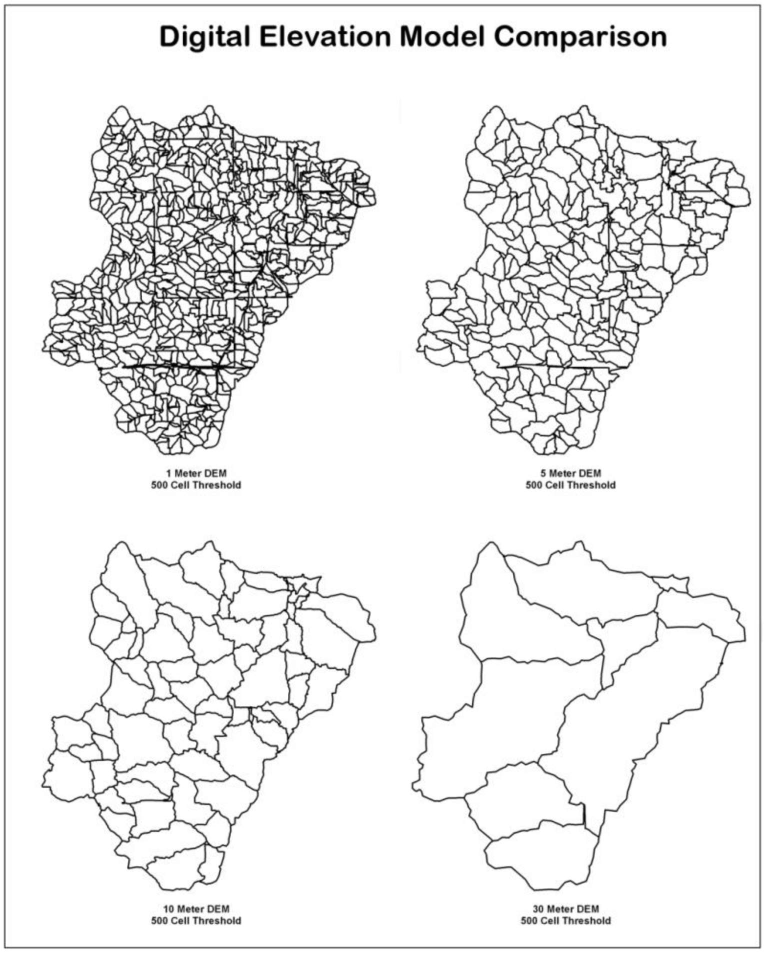

Figure 4: Comparison: 1, 5, 10, 30 Meter DEM

The results of the WinSLAMM modeling demonstrate heterogeneity in estimated levels of pollutants being discharged. The sediment load results (Figure 4A) show the amount of sediments that are predicted to be runoff from each sub-basin. The areas with the highest amount of runoff are within the areas with the highest amount of impervious surfaces. Areas in the southwest of the study area consist mostly of large undeveloped landscapes which are highly pervious resulting in a low predicted pollutant discharge. Central and northern sections consist of many impervious surfaces with small landscapes. These areas also contain high traffic due to parking lots. Areas in the Northeastern section of the study area contain large amounts of clay soil which can negatively contribute to the sediment discharge into waterways.

Also shown are the results from the phosphorus pollutant loads (Figure 4B) estimation. These results show similarities to the sediment loadings as well as high results near the southwestern industrial areas in the study area. The central and northwestern areas consist of maintained landscapes which can contribute to phosphorus loadings due to fertilization which WinSLAMM generates based on the land use classification.

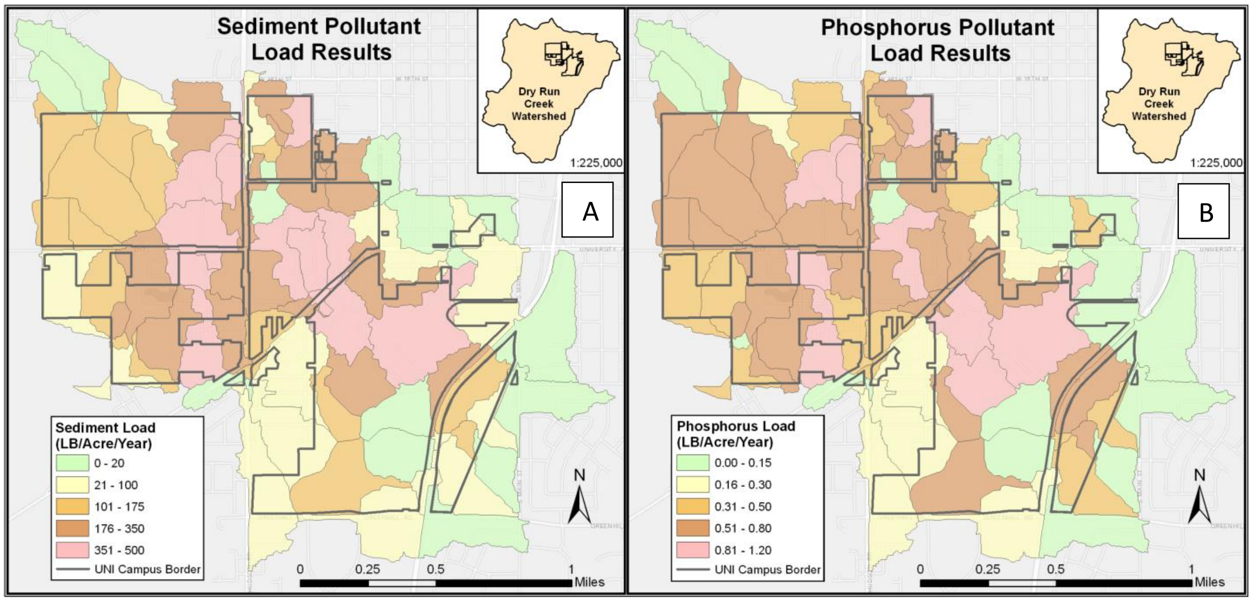

Figure 5: Pollutant Loading Results. A: Sediment Loads. B: Phosphorus Loads.

Five sub-basins were selected from the results based on their phosphorus and sediment outputs as well as available areas within each sub-basin that would have space to implement a biofiltration unit. WinSLAMM modeling scenarios were then carried out based on introduction of these biofiltration units. Each of these sub-basins contains a large amount of impervious surfaces which greatly contribute to the amount of pollutant output. Every sub-basin selected contains grass areas that allow infiltration to take place. The goal is to locate a BMP within a pervious surface that the impervious surfaces will drain into. Shown below are the impervious and pervious surfaces that are within each sub-basin (Figure 6). By locating a BMP within a pervious surface, the runoff from the impervious surfaces will greatly increase the rate of infiltration and reduce the amount of runoff that currently occurs.

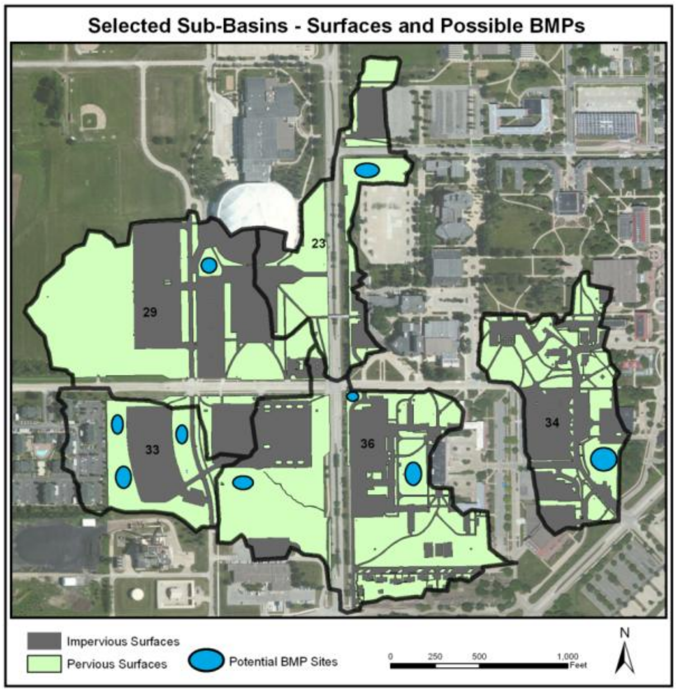

Figure 6: Selected Sub-Basins for BMPs.

The potential BMP sites were located near large areas of impervious surfaces so that the majority of the runoff from these sites could be channeled into the BMP. Not all the sites shown (Figure 6) will contain a BMP but these sites were determined to be the most optimal location within these sub-basins. Detailed information regarding the expected biofiltration units were input into WinSLAMM. Shown below are the specifications of what each BMP will consist of including an expected size, depth, and engineered soil (Table 3).

As you can see many of the biofiltration units do not deviate from a standard structure. Current BMPs on UNI campus follow a similar structure which has been found effective. The only changing variable is the size of the unit itself which is based on the amount of room available and is a major factor in the amount of runoff that will be drained within the BMP. For example, sub-basin 34 contains a large amount of impervious surfaces without much pervious areas so it would require a larger BMP to allow more infiltration to occur. The biofiltration unit also consists of the vertical stand pipe and a broad crested weir for flood control.

Table 3: Expected Biofiltration Cell Details

Sub-Basin BMP	Top Area (sf)	Bottom Area (sf)	Total Depth (ft)	Rock Filled Depth (ft)	Rock Porosity (0-1)	Engineered Soil Infiltration Rate (in/hr)	Engineered Soil Depth (ft)	Engineered Soil Porosity (0-1)	Underdrain, Vertical Stand Pipe, Broad

									Crested Weir
23	7156	7156	8	2	.75	2.5	5	.39	Yes
29	4073	4073	8	2	.75	2.5	5	.39	Yes
33	18621	18621	8	2	.75	2.5	5	.39	Yes
34	24406	24406	10	3.5	.75	2.5	5	.39	Yes
36	16727	16727	9	2	.75	2.5	5.5	.39	Yes

The proposed BMPs were incorporated in WinSLAMM model scenarios and were compared to the previous results without the BMPs. Table 4 shows runoff reductions in both sediment and phosphorus loadings. These biofiltration cells are designed to collect water and allow slow infiltration which would reduce the amount of runoff. The results show large reductions after implementing the biofiltration BMPs. The most significant reductions were in sub-basins 34 and 36. Sub-basin 34 shows the highest reduction amount of total phosphorus loadings with a reduction of approximately 75%.

Table 4: SLAMM Results with Potential BMPs

Sub-Basin	Prior to BMP			After BMP			
	Runoff Volume (cu ft)	Total Pollutant Loading (lbs)	Total Phosphorus Loading (lbs)	Runoff Volume (cu ft)	Percent Runoff Reduction	Total Pollutant Loading (lbs)	Total Phosphorus Loading (lbs)
23	396285	4008	0.2953	152901	61%	1936	4.548
29	1162000	12887	24.5	742865	36%	8459	16.01
33	334269	5233	12.05	71687	79%	1400	3.335
34	5199696	6399	11.59	96689	81%	1388	2.862
36	889441	10648	22	127129	86%	2076	5.057

The goal of this project was to determine if GIS and a LiDAR-derived DEM could produce a more efficient WinSLAMM model. In theory utilizing a DEM with a higher spatial resolution should be effective in modeling the flow of water on the surface. In this project the LiDAR-derived DEM was used to successfully extract the sub-basins within Dry Run Creek through the tools available within ArcGIS and freely available extensions. Within this project it was determined that 1 meter DEM was more efficient to extract sub-basins. However, it would also be suitable to use the 5 meter DEM. The 5 meter was simply more generalized than the 1 meter DEM.

The proposed BMP sites were effective in reducing the amount of pollutants as well as total runoff from entering waterways. These results are modeled estimates and are not to be considered actual amounts. The results are realistic; however the cost of creating the BMP may not be economically feasible. This process of determining pollutant runoff requires a large amount of knowledge of the study area and all the features within it. WinSLAMM can operate without more limited data but will be able to process more realistically the more data available.

Storm water modeling software provides users with estimates of pollutant loadings being discharged from a given area based on multiple criteria. WinSLAMM gives outputs that can be considered reliable based on their multiple decades of research and data verification. Together with the powerful capabilities of GIS, as well as the temporal and high spatial resolution of LiDAR, a more effective WinSLAMM model can be created.

The first objective of this paper shows that high spatial resolution DEMs can be effectively used to determine urban watersheds. This project reports that the most optimal resolution is between 1 and 5 meters which show very similar results. The 1 meter DEM did require more processing to remove errors such as sinks. Compared to common models which use 10 to 30 meter DEMs, the results shown in this project allowed a higher level of detail to be conveyed which is important within a constantly varying environment such as in urban areas. WinSLAMM was effective in modeling potential urban runoff due to its ability to estimate data based on land use classifications. Combined with the high spatial resolution DEMs, it was possible to determine very accurate urban runoffs. WinSLAMM's primary use is for urban planning but it can be an effective way of estimating runoff and pollutant loads from large areas without requiring a large amount of effort in collecting and measuring data through fieldwork.

The future goal of this project is to automate pre- and post-processing of WinSLAMM inputs and outputs through a free extension entitled "ArcSLAMM." This extension will make the entire process undertaken thus far in this project more efficient through a coupling of ArcGIS, databases, and WinSLAMM.

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Information Transfer Program Introduction

The Iowa Water Center organizes and conducts education and outreach activities throughout the year. The focus of the Iowa Water Center 2011 Information Transfer Project was on educating the public concerning the quality of water resources and the impacts of best management practices on these resources. Center activities take the form of conferences, scientific poster symposiums, field days, special publications, web page updates, and informational documents for educators and the general public

Information Transfer Project

Basic Information

Title:	Information Transfer Project
Project Number:	2011IA245B
Start Date:	3/1/2011
End Date:	2/11/2012
Funding Source:	104B
Congressional District:	4
Research Category:	Not Applicable
Focus Category:	Education, Water Quality, Agriculture
Descriptors:	
Principal Investigators:	Richard Cruse, Hillary Ann Olson

Publication

1. Authors (Jim Newman, Rick Cruse, Brian Ritter, William Crumpton, Erwin E. Klaas, Richard C. Shultz, Thomas M. Isenhart, K.J. Franz, Kayla J. Steffens, Mimi Wagoner, Hugh J. Brown, Thomas E. Fenton, Richard Jensen, Dan B. Jaynes, Rob Malone, Kelly Thorp, Xiangwei Chen, Enhen Wang, Jackie Hartling Stolze, Douglas L. Karlen), 2011, "Getting into Soil and Water," for copies contact Rick Cruse, 39p

The Iowa Water Conference held 7 and 8, March 2011 on the Iowa State University campus attracted 425 participants. The conference theme was: "More Water to Manage." Conference partners included the Iowa Department of Agriculture and Land Stewardship, Iowa Department of Natural Resources, Iowa Association of Municipal Utilities, the Leopold Center for Sustainable Agriculture, Iowa Flood Center, Iowa Floodplain and Stormwater Management Association, Iowa Learning Farms, Iowa State University Extension, the Iowa Water Center, and the Iowa Storm Waters Education Program. The conference was expanded to a two-day venue.

Multiple outreach activities were conducted with the Iowa Learning Farm (ILF). These included presentations at field days across Iowa addressing a range of water related issues associated with agricultural management practices. The IWC was engaged to strengthen water related educational activities of the ILF. The IWC also partnered with the ILF on a funded proposal titled: Water Rocks. The IWC will receive support for the program coordinator (average 0.12 FTE) for the next two years from this grant.

The IWC developed with the ISU Soil and Water Conservation Club our third annual educational /outreach publication, titled "Getting into Soil and Water." Approximately 1,600 copies have been distributed in Iowa, including to Iowa high school science teachers, potential students visiting the Environmental Science program in the College of Agriculture and Life Sciences, Iowa DNR offices, all Natural Resources Conservation Service offices in Iowa, selected ISU alumni, Iowa Extension offices, all attendees of the Iowa Water Conference, and the Iowa Environmental Council.

Multiple invited presentations were given by the director addressing water and water related issues, include the following:

1. **Cruse, Richard M.** 2011. *Biofuels, climate change and hydrology: A tsunami of challenges*. Presented at Low Carbon Economy: EU Energy and Environment Innovations. The Hungarian EU Presidency 2011 - Open University Programme. St. Istvans University. Gödöllő, Hungary. April 8.

2. **Cruse, Richard M.** 2011*. Climate change impacts on Iowa.* Presented at Inquiry Approaches to Climate, Weather, and Energy in the 6–9 Classroom. Center for Global and Regional Environmental Change. University of Iowa. Iowa City, IA. June 13.

3. **Cruse, Richard M.** 2011. *Climate change, natural resource degradation and the American dream.* Guest lecture in, "Environmental Challenges and Responses." Grinnell College, Grinnell, IA. October 7.

4. **Cruse, Rick and Scott Staggenborg.** 2011. *Climate change impact on crop performance and soil and water.* Presented at Agricultural Decision Making with a Water and Climate change Perspective. Heartland Regional Water Coordination Initiative. Nebraska City, NB. November 2, 2011.

5. **Cruse, Richard M.** 2011. Climate Change and Agriculture. Presented at Forum on Adaption: Farm Production, Risk Management, Food Security and Changes in Weather and Climate. Bipartisan Policy Center. Washington DC. November 18.

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The IWC director led the development of a peer reviewed document jointly published by the IWC and Council for Agriculture Science and Technology (CAST); the publication addresses land management impacts on stream water quality in agricultural watersheds. The document draft was completed in 2011, was reviewed in the fall of 2011 and ultimately published in March 2012.

USGS Summer Intern Program

None.

Notable Awards and Achievements

Chapter Achievement Award- SWCS; The Iowa State University Soil and Water Conservation Club which partners with the Iowa Water Center has received the Soil and Water Conservation Society's Chapter Achievement Award. The student organization published its fourth annual educational /outreach publication, titled "Getting into Soil and Water." Approximately 1,600 copies have been distributed in Iowa, including to Iowa high school science teachers, potential students visiting the Environmental Science program in the College of Agriculture and Life Sciences, Iowa DNR offices, all Natural Resources Conservation Service offices in Iowa, selected ISU alumni, Iowa Extension offices, all attendees of the Iowa Water Conference, and the Iowa Environmental Council.

Information Transfer Program Introduction

The Iowa Water Center organizes and conducts education and outreach activities throughout the year. The focus of the Iowa Water Center 2012 Information Transfer Project was on educating the public concerning the quality of water resources and the impacts of best management practices on these resources, as well as launching a new website. Center activities take the form of conferences, scientific poster symposiums, field days, special publications, and informational documents for educators and the general public.

Information Transfer Project

Basic Information

Title:	Information Transfer Project
Project Number:	2011IA181B
Start Date:	3/1/2012
End Date:	2/28/2013
Funding Source:	104B
Congressional District:	Iowa 004
Research Category:	Not Applicable
Focus Category:	None, None, None
Descriptors:	None
Principal Investigators:	Richard Cruse, James K. Newman

Publications

1. Authors (Richard Cruse, Aaron Lee Daigh, Clay Robinson, Craig Cox, Andrew Hug, Nils Bruzelius, Jerry Hatfield, Jim Gillespie, James R. Russell, Kathleen Delate, C. Lee Burras, mark D. Tomer, Tom Loynachan), 2012, Getting Into Soil and Water, copies available from Iowa Water Center and electronically on water.iastate.edu, pp.30.
2. Authors (Richard Cruse, Don Huggins, Christian Lenhart, Joe Magner, Todd Royer, Keith Schilling), 2012, Assessing the Health of Streams in Agricultural Landscapes: The Impacts of Land Management Change on Water Quality, available through CAST and the Iowa Water Center, pp42.

2012-13 Iowa Water Center Information Transfer Project

The Iowa Water Center (IWC) organizes and conducts education and outreach activities throughout the year. It additionally participates in multiple events lead by other groups in the state. Center activities take the form of conferences, scientific poster symposiums, field days, special publications, educational programs, and informational brochures for educators and the general public. The Iowa Water Conference has been one of the Center's most noteworthy outreach activity with attendance growing from 145 the first year (2007) to 450 in 2011. The 2012 conference was a joint partnership of eight groups, including state and federal agencies, nonprofit organizations, and state research centers addressing Iowa water issues. It was held March 6 and 7, 2012 in Ames, Iowa. The theme was "Improving Iowa Watersheds: Striking the Right Balance." The keynote speaker was Robert Hirsch, U.S. Geological Survey, on "Trends in Nutrient Flow from the Upper Midwest".

The 2012 conference included synergistic contributions from Iowa Department of Ag and Land Stewardship; Iowa Flood Plain Management Association; Iowa Storm Water Education Program; Iowa Department of Natural Resources (IDNR); Iowa Flood Center; Iowa Learning Farms, Trees Forever, the Center for Global and Regional Environmental Research, and the Leopold Center for Sustainable Agriculture. A poster display and a sponsor/vendor session were held concurrently with the conference to promote awareness of research and/or outreach activities between individuals and organizations. IWC also played a role in developing the 2013 Heartland Regional Water Conference held in April 2013 and is taking a part in the formation of the North Central Region Water Coordination Initiative.

The IWC co-produced the publication "Getting into Soil and Water" in cooperation with the Iowa State University (ISU) student Soil and Water Conservation Club. This 30 – 40 page annual educational publication addressing soil and water related issues was initiated in 2009 and is dominantly self-supporting through donations from soil and water related groups, student volunteers, and financial support from the club. The IWC has contributed $1,500 annually towards this product. This publication was distributed to all attendees of the Iowa Water Conference, Iowa high school science teachers, all Natural Resources Conservation Service Offices in Iowa, former club members, selected departmental offices at ISU, and potential students visiting ISU for the Agronomy and Environmental Science undergraduate degree programs. In 2012, a request was made for the publication to also be delivered to Iowa high school vocational agriculture teachers. It is available for download at http://www.water.iastate.edu/sites/www.water.iastate.edu/files/iowawatercenter/bookDraft_20120222.pdf.

The IWC partners with the Iowa Learning Farms (ILF) and received support from the Leopold Center, IDALS, and IDNR for partnering in numerous water related outreach activities across the state. These activities target farmers, high school students, businesses, and both for profit and nonprofit organizations. In 2012, through field days more than 9,400 clients were served.

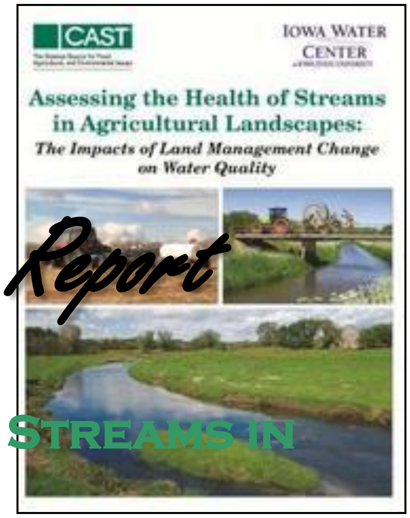
Many faculty members involved in IWC research project have complimentary extension/outreach responsibilities. The IWC encourages participation of faculty in its outreach activities, promoting dialog and cooperation among state water professionals from multiple organizations. At the Iowa Water Conference in 2012, selected seed grant recipients of IWC funds presented in a special session designed to deliver to stakeholders research outcomes resulting from these funds.

IWC members gave multiple presentations at the request of faculty members. Specific examples include a series of presentations at the 2012 Farm Progress Show and presentations across the state with the Iowa Learning Farm Conservation Station. The IWC is a key partner in the ISU Climate & corn-based cropping system proposal team, which won a $19,927,691 grant from USDA 2010. The Iowa Water Center is charged with leading the organization of at least one national level conference to present project results prior to the end of this five year project.

In 2012 the Iowa Water Center released with the Council for Agriculture Science and Technology (CAST) a peer reviewed report addressing the impact of land management change on stream water quality. This report, a combination of research and outreach was released at the Iowa Water Conference on March 6, 2012 and was rolled out in Washington DC March 26, 2012. IWC has presented this publication in many arenas, most notably at the 2012 Gulf Hypoxia Task Force Fall meeting in Des Moines, IA on Sept 11, 2012. An impact report through May 2012 has been included at the end of this document.

Perhaps the largest undertaking in 2012 was the redesign of the Iowa Water Center website. IWC contracted with ISU Extension IT services to completely redo the website to create a functional website that broached a broader audience with fresh content. The website rolled out in July 2012 and includes resources for researchers, farmers, educators, students, and the general public. It also includes a "water expert directory," where water professionals from across the state can input their information voluntarily to connect with other professionals and those with questions. The website frequently receives questions regarding private wells, water quality, and water research, among other topics. The "Contact Us" and "Ask a Water Expert" features are used an average of 1-5 times per month. From Aug 1, 2012 – Feb 28, 2013, the website had 1003 unique visitors that made up a total of 2,170 visits and 6,118 page views.

In June of 2012, a new Program Coordinator was hired with experience in marketing, including online social media. The Iowa Water Center holds accounts on Twitter, Facebook, and has created a bi-monthly annual newsletter. The Twitter account in the most popular, with over 100 followers; Facebook has 46 followers and the newsletter has approximately 85 subscribers. IWC has also increased its presence at local conferences, including exhibiting at the Iowa Environmental Council and Practical Farmers of Iowa annual conferences.



CAST Publication Impacts Report

Assessing the Health of Streams in Agricultural Landscapes: The Impacts of Land management Change on Water Quality

CAST Special Publication 31
Released: March 06, 2012
Report Compiled: March 06–April 30, 2012
Chair: Dr. Richard Cruse, Professor in Agronomy, Iowa State University, Ames

I. Rollout/Release

The health of streams in agriculturally dominated watersheds has long been assumed to be almost entirely dependent on nearby agricultural practices. In that regard, governments are making substantial investments in the modification of agriculture production activities. Conservation practices have reduced nutrient, sediment, and contaminant loads to those streams, but evidence remains strong that water quality and stream health, especially of those streams draining into the Mississippi River, are still a challenge.

II. Distribution of Announcements/News Releases

Electronic Contacts

Listservs

Task Force Members

Board/Staff
Society Presidents
Society Executives

Friday Notes recipients
Media

News Information Groups
Deans of Agriculture
Directors of Ag Experiment Stations

III. Follow-On Activities/Presentations/Newspaper Articles/TV and Radio News

- March 6–7, 2012, Iowa Water Conference held at Iowa State University, Scheman Continuing Education Building, in Ames, Iowa. Dr. Rick Cruse spoke about Special Publication 31. http://www.aep.iastate.edu/iwc/program/1-am.html
- Dr. Donald Huggins, Kansas Biological Survey, and Dr. John Bonner presented *A Diagnosis of Troubled Waters*, featuring *Assessing the Health of Streams in Agricultural Landscapes: The Impacts of Land Management Change on Water Quality.* Monday, March 26, 2012, Washington, D.C.
- National Coalition for Food and Agricultural Research (NC-FAR) had a "Lunch 'n Learn" Seminar on Monday, March 26, 2012, where Dr. Donald Huggins presented the publication.

V. Internet and Website Connections (total collected: 21 as of July 16, 2012)

Ag Professional
Accessed March 06, 2012
http://www.agprofessional.com/news/New-CAST-paper-assesses-health-of-streams-in-ag-landscapes-141574793.html

AGFAX.com
Accessed March 26, 2012
http://agfax.com/2012/03/26/no-quick-fix-on-water-quality/

Agribiz.com
Accessed April 12, 2012
http://agribiz.org/wp-content/uploads/2012/04/Fert-industry-resp-EWG-4-12-12x.pdf

CAST Constant Contact Rollout Announcement
Accessed March 28, 2012
http://www.cast-science.org/news/index.cfm?show=rss

CAST Rollouts
Accessed March 28, 2012
http://www.cast-science.org/news/?agriculture_and_stream_water_quality_new_cast_publication_featured_in_dc_rollouts&show=news&newsID=12640

Environmental Law Institute (ELI)
Accessed March 2012
http://www.eli.org/Program_Areas/tmdl/tmdl.background.2012.cfm

Iowa State University; Ag and Life Sciences ONLINE
Accessed March 12, 2012
http://www.ag.iastate.edu/news/agonline/714/

Iowa State University Iowa Water Conference
Accessed March 7, 2012
http://www.aep.iastate.edu/iwc/program/2-am.html

Mrbdc.mnsu.edu
Accessed 2012
http://mrbdc.mnsu.edu/sites/mrbdc.mnsu.edu/files/public/org/mrbd/pdf/Near_Channel_Lenhart.pdf

NC-FAR
Accessed March 20, 2012
http://www.ncfar.org/NCFAR_Media_Advisory_Ag_Water_032612.pdf

NC-FAR Program
Accessed March 26, 2012
http://www.ncfar.org/Ag_Water_Program_032612.pdf

Oklahoma Farm Report
Accessed March 06, 2012
http://oklahomafarmreport.com/wire/news/2012/03/02255_AgStreams03062012_101601.php

Oklahoma State University; Water Resources Center
Accessed March 26, 2012
http://water.okstate.edu/news-events/conferences/cast-presentation-a-diagnosis-of-troubled-waters

Pork Network
Accessed March 07, 2012
http://www.porknetwork.com/pork-news/latest/New-CAST-paper-assesses-health-of-streams-in-ag-landscapes-141574793.html

The Fertilizer Institute (TFI)
Accessed April 13, 2012
http://www.tfi.org/media-center/news-releases/fertilizer-institute-responds-environmental-working-groups-troubled-water?colorbox=1&section=news-releases

The Progressive Farmer
Accessed April 13, 2012
http://www.dtnprogressivefarmer.com/dtnag/common/link.do;jsessionid=C9639041DADE64D1A354F78CD4B0C4FF.agfreejvm2?symbolicName=/ag/blogs/template1&blogHandle=policy&blogEntryId=8a82c0bc35e51c220136ad54fa7807df

University of Kansas
Accessed March 23, 2012
http://www.news.ku.edu/2012/march/23/water.shtml

University of Kansas; Central Plains Center for BioAssessment
Accessed March 2012
http://www.cpcb.ku.edu/

University of Minnesota
Accessed March 2012
http://www.bbe.umn.edu/People/Lenhart/index.htm

University of Wisconsin–Madison Libraries
Accessed March 2012
http://search.library.wisc.edu/catalog/ocn781260480

Vwrrc.vt.edu
Accessed May 08, 2012
http://vwrrc.vt.edu/vwmc/announcements/announcements_2012_May8.pdf

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	1	4
Masters	2	1	0	0	3
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	6	1	0	1	8

Notable Awards and Achievements